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THE UNIVERSITY OF ALBERTA

A STRATIGRAPHIC STUDY OF THE REGINA BASIN, SASKATCHEWAN

A THESIS

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The undersigned certify that they have read and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "A Stratigraphic Study of the Regina Basin, Saskatchewan", submitted by Denis L. Delorme, B.A. in partial fulfilment of the requirements for the degree of Master of Science.

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ABSTRACT

The Regina Basin area (National Topographic series maps 72 Hand I, 62-E) comprises 6260 square miles, lying between 103° 50' and 106° 00' West Longitude and between 49° 50' and 50° 45' North Latitude in southeastern Saskatchewan.

The surficial sediment is mainly lacustrine silt and clay. The thickness of lacustrine sediment ranges from a few feet near the edge of the basin to 35 feet in front of the Condie Moraine. Stratigraphically, the lake silt and clay is divided into three units. Moose Jaw Clay was deposited during the first lake phase, Regina Clay was deposited during the second lake phase, and Condie Clay was deposited during the third and last lake phase. The Regina Basin drained completely between the phases forming a dry plant-bearing surface. Organic debris and gypsum mark the hiatuses between the units.

The Rouleau Basin within the Regina Basin was formed by faulting probably by salt-solution collapse along a transcurrent fault parallel to the Missouri Coteau. A depression of approximately 40 feet occurring on the surface of the Upper Cretaceous bedrock outlines the Rouleau Basin.

Isostatic adjustment in the Regina Basin is marked by five isobases. Delineation of the isobases is complicated by faulting in the basin.

Nineteen species belonging to 7 genera of Ostracoda are figured and described from the sediments of the Regina and Rouleau Basins and the Qu'Appelle Valley fill. Seven species of Ostracoda are proposed as new. On the basis of ostracods and molluscs, the Qu'Appelle Valley fill is divided into five distinct depositional environments.

A STRATIGRAPHIC STUDY OF THE REGINA BASIN,

SASKATCHEWAN

By D.L. Delorme, B.A.

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INTRODUCTION

Location and Previous Work

The Regina Basin comprises approximately 6260 square miles, lying west of the second meridian between 103° 50' and 106° West Longitude and between 49° 50' and 50° 45' North Latitude (Figure 1).

Prior to the time of Davis (1918) no one had actually described the Regina Basin. Henry Youle Hind (1859) reported an ancient lake in what he called the valley of the South Saskatchewan. Upham (1891) later referred to this ancient lake as "Glacial Lake Saskatchewan" and considered it to have been formed by ice damming. He also inferred drainage first to Lake Souris through the Waskana River and later through the Qu'Appelle Valley. Davis, who did field work in 1915 and 1916, described and named Glacial Lake Regina as a large body of water dammed by an ice sheet to the north and extending southeast of the Qu'Appelle Valley to Weyburn. He believed that the main source of water came from overflowing lakes occupying the South Saskatchewan River valley. From a study of the relief, Stansfield (1917) deduced that the clay of the "Regina Plain" forming the present surface, was till and not lake clay. Work done by Johnston and Wickenden (1930) gave a clearer picture as to the outline of the lake basin and character of the lake sediment. They found that the lake clay was weathered to a depth of 5 to 7 feet.

Christiansen (1961) reported on the geomorphology of the Regina Basin and produced an isopach map of the lacustrine clay. He found evidence of an end moraine and traced and named the margin of the Condiean readvance into the basin. Christiansen (1961, p. 42) dated this readvance

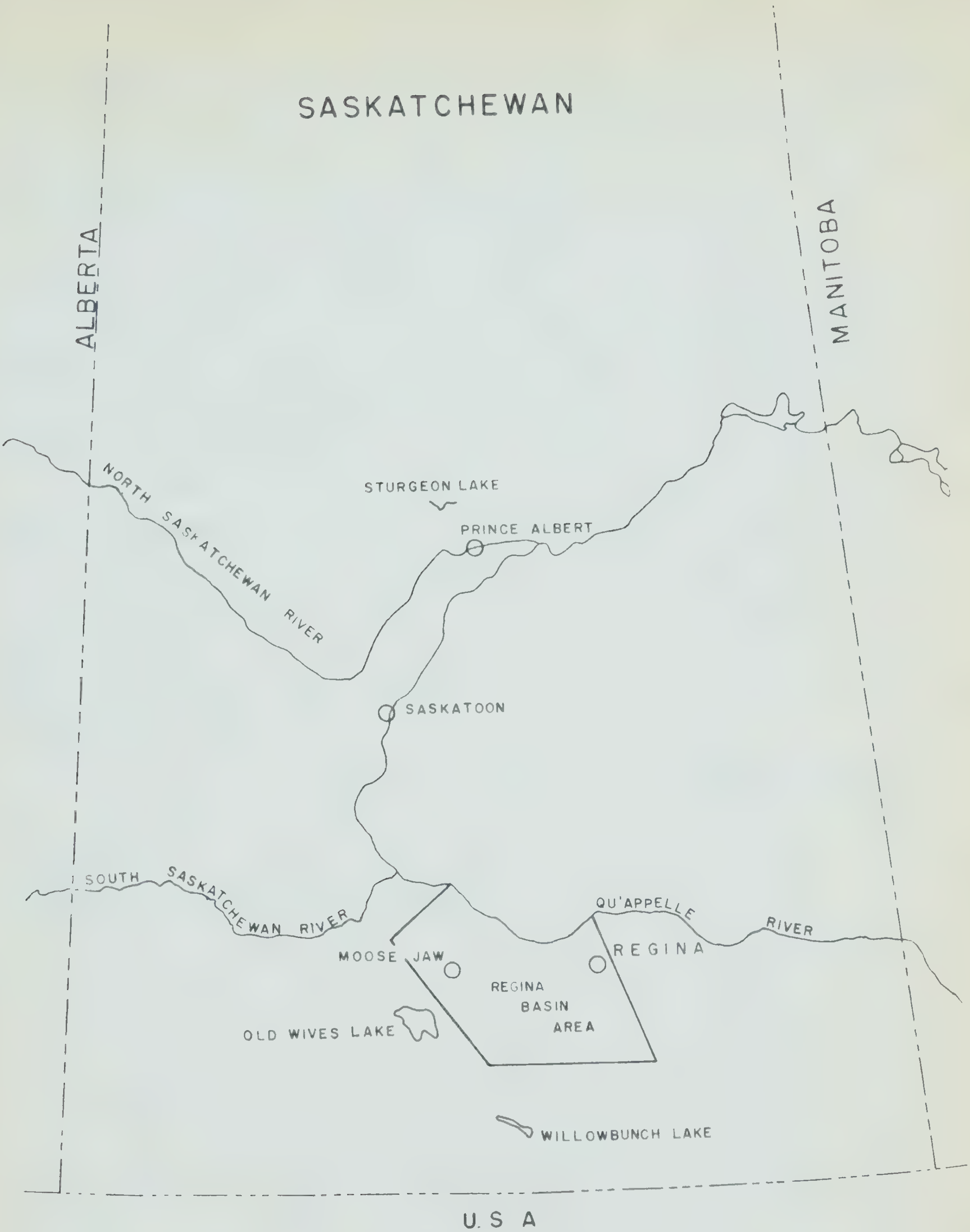

FIGURE 1.—LOCATION OF MAP-AREA

as correlative to the Valders maximum at 10,150 $\pm$ 200 B.P. He held that the basin was filled with water once, and that during the interval preceding the readvance the basin never drained.

Present studies

This report is based on field investigations conducted from June to August 1960 and laboratory studies from 1960 to 1962. Laboratory work was carried out at the University of Alberta.

The soils map (Mitchell *et al.*, 1947) was used as a guide in determining contacts of surficial sediments. Aerial photographs and mosaics were used with the soils map in the study of land forms. Preliminary interpretations were checked in the field at which time stratigraphic details were obtained. Field information was plotted on 1:50,000 field maps.

This report elaborates and supplements the geologic history of the Regina Basin originally set forth by Dr. E. A. Christiansen of the Saskatchewan Research Council (1961).

SUMMARY OF THE GLACIAL HISTORY

One purpose of this report is to define in greater detail the stratigraphy of the Regina Basin. Christiansen (1961) prepared a general report on the Regina area which contains the major portion of the Regina Basin.

The Regina Basin, as defined in this report (Plate in pocket), is an elongate depression between uplands to the east and west. The basin is not a drainage basin but rather a depression in which meltwater accumulated during the retreat of the Wisconsin ice front. In effect, the depression was not a closed basin because the glacier formed the closure to the north, therefore, when the basin became filled with water it formed a true glacial lake.

The stratigraphic history of the sediments deposited in the basin is divided into three parts or phases. Each phase is related to a single filling of the basin and subsequent drainage. The Moose Jaw phase or first phase began with the melting of glacial ice and uncovering of the Regina Basin. The glacier at this time was in the form of a lobe, called the Weyburn Lobe (Christiansen, 1956). As the ice melted, meltwater poured off its three free sides and drained through the Souris Spillway at the south end of the basin. The channels formed along the retreating edges of the ice are called unilateral channels. The streams in these channels eroded the till bottom of the basin. Later when the glacier had retreated further north these broad channels filled with meltwater and formed Glacial Lake Moose Jaw. The sediment deposited in Lake Moose Jaw consists of clay and silt-sized particles forming the lacustrine Moose Jaw Clay. Lake Moose Jaw eventually dried up leaving a lake plain

on which plants could grow. Leaching of the top sediments occurred as evidenced by the decrease in amount of sulphates.

A reactivation of the ice front after Lake Moose Jaw drained caused the Regina Basin to be filled with water for a second time, forming Glacial Lake Regina. During this interval, the water level was much higher covering parts of the basin which had not been inundated during the Moose Jaw phase. Small beaches, as short discontinuous strandlines, formed in the northeastern and northwestern portions of the basin. The sediment deposited in Glacial Lake Regina consists of clay and silt-sized material. The lacustrine Regina Clay is partially oxidized because of the aerated condition of the lake water. When the ice front retreated, the water drained east by a small channel now occupied by the Qu'Appelle River. Thunder Creek, which drained proglacial areas to the west of the Regina Basin, emptied its meltwater into the newly formed Qu'Appelle Channel. Lake Regina dried up leaving a lake plain on which plants grew.

The final readvance of the glacier into the Regina Basin is marked by the Condie Moraine, the terminus of the ice front. During this time, the Regina Basin was once again filled with meltwater, with a water level higher than in the previous phase. It is estimated that prior to draining of the basin, the water was 50 feet deep. As the Condiean ice advanced into the basin, an apron of silt-sized sediment was deposited marginal to the Condie Moraine which extended out into the lake. As the ice front retreated, lake sediments became finer, forming what is now the surficial sediment known as the Condie Clay.

While the Condie Moraine was being formed, volcanic activity, thought to have originated in north-central Washington, deposited volcanic

ash on the Condie Moraine before all the ice had been melted from the till. No date has been obtained for the ash as yet, however a radiocarbon date of 10,150 ± 200 years B.P. from near Kenaston, Saskatchewan (Christiansen, 1961, p. 42), beneath Condie Till dates the Condie advance as correlative to the Valders maximum.

During the final stages of Glacial Lake Condie, faulting is thought to have occurred in the Rouleau area forming the Rouleau Basin. This basin is small in comparison to the Regina Basin, however, its position parallel to the Missouri Coteau face is of great significance. The small basin is surrounded by the Condie Plain. It received its sediment, clay-sized material, by mass wasting of the fault scarp. In contrast to the water in Lakes Regina and Condie, the water in Lake Rouleau was much warmer and somewhat stagnant, consequently organic matter was preserved; ostracods and molluscs quickly inhabited the environment. Sedimentation of the basin and the approaching nick point in Moose Jaw Creek drained the Rouleau Basin in recent time.

Isostatic adjustment in the Regina Basin has occurred, but, because of the scarcity of well defined beaches and strandlines the delineation of isobases has been very difficult. Based on the fact that the strandline of Glacial Lake Condie is 50 feet higher than the lacustrine clay-till contact, the writer has attempted to outline five isobases. Because vertical adjustment of the earth's crust by faulting has occurred in the area, the position and direction of the isobases have been ascertained with difficulty.

The Qu'Appelle Valley is not a part of the Regina Basin but borders its northern edge; since it governed the drainage history of the

basin, it is dealt with in considerable detail in this report. Christiansen (1961) described one of its lithologic units as being made up of Regina Clay (Regina and Condie Clays of this report) and prompted an investigation by the writer as to the relationship of the Qu'Appelle Clay and the Regina and Condie Clays of the Regina Basin. It was found that Christiansen's "Regina Clay" was much younger than the sediments of the Regina Basin, and warranted the proposed name, Qu'Appelle Clay. The Qu'Appelle River system was found to be part of a much larger system draining proglacial areas of Alberta, Saskatchewan, and Manitoba. When a lower outlet was uncovered (North Saskatchewan River draining into Lake Winnipeg) the Qu'Appelle River was captured by the South Saskatchewan River leaving the remnant Qu'Appelle River as a misfit stream in an oversized valley. Sedimentation of the valley occurred when bedrock exposures in the valley walls became supersaturated and slumped into the valley forming dams. At about the time that the Saskatchewan outlet was uncovered, sedimentation of the river systems neared completion. The Qu'Appelle Clay is conformably overlain by Qu'Appelle Alluvium.

STRATIGRAPHY

General Statement

The glacial history of the Regina Basin can be established by a study of stratigraphic sequences of till and inter-till deposits, supplemented by palaeontological and geochemical data (Figure 1a). As pointed out by Christiansen (1961, p. 31) there are at least two tills in the area in addition to the lake deposits.

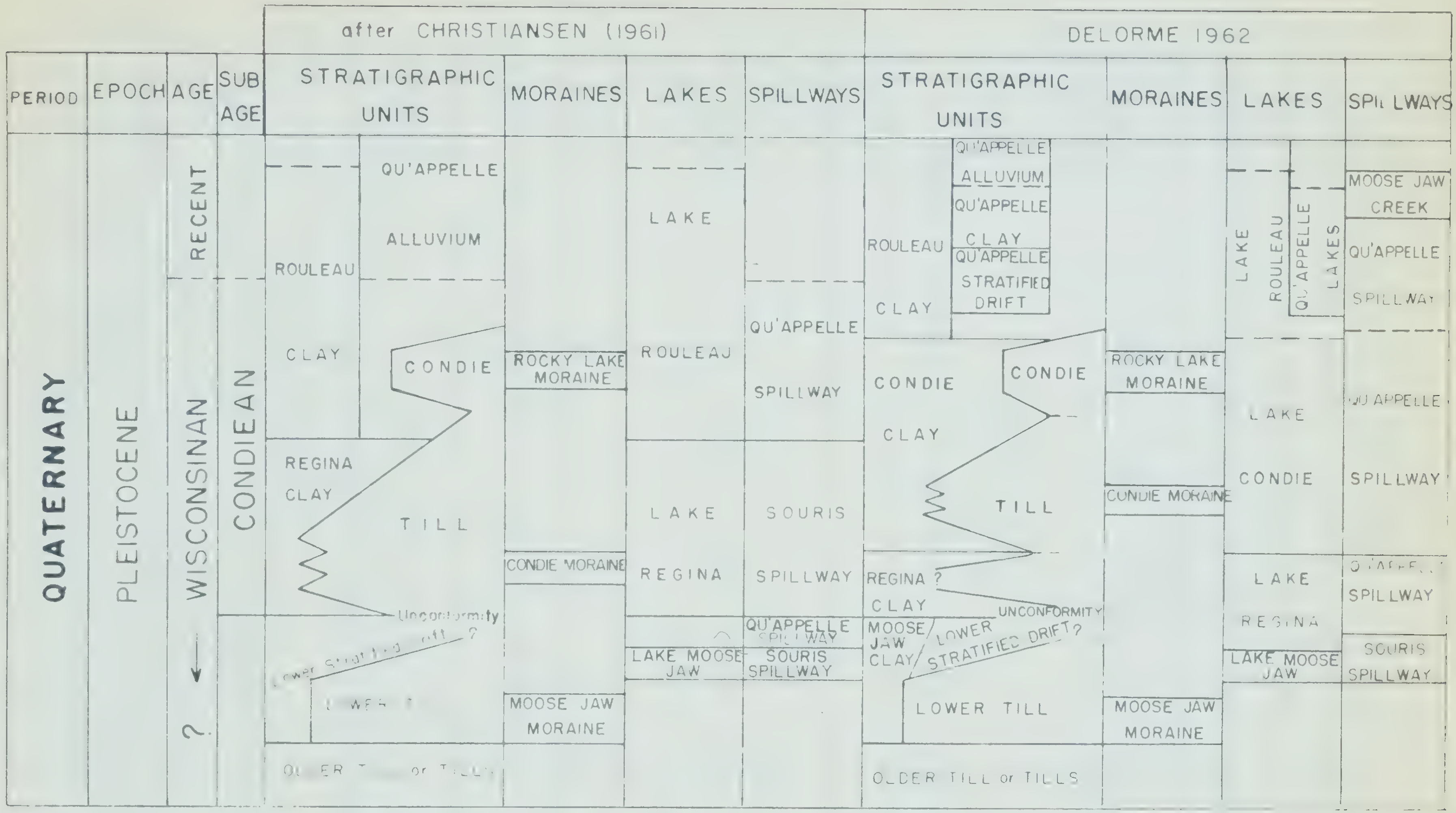

FIGURE 1a — SUMMARY OF PLEISTOCENE AND RECENT STRATIGRAPHY IN THE REGINA BASIN

Lower Till

This unit was named and described by Christiansen (1961, p. 31). Because of poor exposures, the full thickness of the unit is not exposed in any one section. The Lower Till apparently forms the floor of the Regina Basin. Portions of it were eroded by the formation of unilateral channels during the Moose Jaw phase. The Lower Till that was not eroded was oxidized.

Moose Jaw Clay

General Statement.- The name Moose Jaw Clay is proposed by the writer for the lacustrine clay which was deposited in the first lake phase of the Regina Basin (Figure 1a). The name is taken from the city of Moose Jaw. The reference section of the Moose Jaw Clay is in a test-hole in the N.E. corner of Section 30, Township 14, Range 23 (Section 1, Appendix). In the sourthern part of the Rouleau Basin (sec. 22, tp. 13, rge. 22, W. 2nd mer.) samples from a test hole show that the Moose Jaw Clay is at least 4 feet thick. South of the Condie Moraine samples from test holes show that the Moose Jaw Clay overlies oxidized Lower Till disconformably. South of Moose Jaw, a facies change occurs from gravels through sands to silts. A similar facies change occurs in the eastern extension of Lake Moose Jaw bordering the kame-eskerine complex from Pilot Butte to St. Peters Colony south.

Composition.- The Moose Jaw Clay is composed of clay, silty clay, and silt. Silt becomes predominant towards the north. The lake clay is calcareous, olive brown, montmorillonitic and oxidized. Partial oxidation occurred during deposition of the clay with subsequent oxidation

after formation of a weathered surface. In core samples, organic matter is readily discernible indicating plant growth. Complete leaching of the soil did not occur, but there is evidence of local leaching and subsequent replacement of rootlets by gypsum.

Lower Stratified Drift

General statement.- This unit was named and described by Christiansen (1961, p. 31) as lying between the Lower Till and the Condie Till north of the Condie Moraine (Figure 1a). It is possible that the Lower Stratified Drift was proglacial drift deposited by the retreating glacier at the same time that the Moose Jaw Clay was being deposited. This unit is conformable with the Lower Till indicating that the till surface is higher in elevation north of the Condie Moraine.

Composition.- The drift is composed of clay, silt, and sand, and in thickness varies from 2 feet to more than 38 feet indicating variable conditions of deposition. Generally, the unit is calcareous and shows little signs of having been weathered. Coarse gravels above sands in some sections may indicate local reactivation of the ice front.

Regina Clay

General statement.- The name Regina Clay is proposed by the writer for the lacustrine clay deposited in the second lake phase of the Regina Basin. The name is taken from the city of Regina. The Regina Clay as interpreted by the writer (Section 1, Appendix) represents the lower part of the "Regina Clay" named and described by Christiansen (1961, p. 35), and is the bottom 11 feet of his section. Occasional remnants of this unit may still be present beneath the Condie Moraine, but this has not

been positively ascertained. It ranges in thickness from 1 to 15 feet. Perhaps the clay and silt unit exposed north of Chamberlain represents a northern extension of the Regina Clay as it is overlain by Condie Till.

Composition.- The Regina Clay is composed of clay, silty clay, and silt. The silty clay and silt become more noticeable towards the north. The clay is calcareous, light-greyish brown, montmorillonitic, and slightly oxidized. The top of the Regina Clay is marked by a weathered surface on which plants grew and sent their roots into the clay. These rootlets subsequently became the loci for the local accumulation of selenite by local leaching of the clay-sized sediment.

Condie Till

General statement.- This unit was named and described by Christiansen (1961, p. 31). From various sections, the thickness is found to range from 10 to 185 feet. The terminus of the unit is marked by the Condie Moraine. The till rests unconformably on the Lower Stratified Drift; the Regina Clay having been removed on the readvance of the glacier (Figure 1a). The Condie Till is well exposed in the Waskana Creek Valley, Cottonwood Creek Valley, and in the Qu'Appelle Valley.

Composition.- The Condie Till is a calcareous, oxidized to unoxidized, montmorillonitic, sandy clay loam to clay loam.

Condie Clay

General statement.- The name Condie Clay is proposed by the writer for the silt and clay deposited in the third lake phase of the Regina Basin (Figure 1a). It is exposed on the surface south of Qu'Appelle Valley. The name is taken from the hamlet of Condie. This unit is

correlative with the Condie Till. The Condie Clay is present both north and south of the Condie Moraine, the area having been inundated as the ice retreated north to the Qu'Appelle Valley. South of the Condie Moraine, samples from test holes show that the Condie Clay overlies the Regina Clay conformably. Further, these samples show that there is 11 feet of silt overlain by 11 feet of clay. As shown by Christiansen's (1961, p. 33) cross section of the Regina area, silt related to the Condie readvance underlies lake clay. In front of the Condie Moraine there is an anomalous thickness of silts related to erosion of Regina Clay as indicated in the Hungry Hollow section (Christiansen 1961, p. 33, 35, 68). The top 22 feet of his Section 17 represents the Condie Clay of this report.

Composition.- The Condie Clay is composed of clay, silty clay, and silt. The silt and silty clay become thicker as the Condie Moraine is approached. The lake clay is calcareous, olive brown, montmorillonitic, and slightly oxidized. In some localities where deposition was close to the ice front, flat lying or contorted varves occur.

Rouleau Clay

General statement.- This unit was named and described by Christiansen (1961, p. 37). The Rouleau Clay is present only in the Rouleau Basin. It has a thickness which varies from 11 to 16 feet. The Rouleau Clay rests conformably on the Condie Clay (Figure 1a).

Composition.- The Rouleau Clay is calcareous, montmorillonitic, grey, oxidized to unoxidized. The lower 2 or 3 feet of the unit is oxidized. In the reference section a high sulphate-carbonate zone occurs 14 feet below the surface (Figure 7). The sediment source was mainly from the Regina and Condie Clays, but some sediment was derived from the Lower Till, and from the bedrock of the Missouri Coteau.

Qu'Appelle Stratified Drift

General statement.- This unit was named the Lower Stratified Drift by Christiansen (1961, p. 38). This glacial drift lies above bedrock and below the Qu'Appelle Clay of the writer except in the Regina Valley (Christiansen, 1961, p. 39) where it lies on till. The unit ranges in thickness from 10 to 15 feet.

Composition.- The Qu'Appelle Stratified Drift is composed of medium to coarse sand derived mainly from the till.

Qu'Appelle Clay

General statement.- This unit was named as the "Regina Clay" by Christiansen (1961, p. 38). In Christiansen's section, this unit has a thickness of 100 feet being overlain by Qu'Appelle Alluvium 30 feet from the surface of the Qu'Appelle Valley.

Composition.- The Qu'Appelle Clay is composed of clay, silty clay and silt. The clay and silty clay are calcareous, unoxidized, grey, and montmorillonitic. The top 20 feet of the section is only slightly calcareous. Much organic matter is present throughout the section.

Qu'Appelle Alluvium

General statement.- This unit was named and described by Christiansen (1961, p. 38). The Qu'Appelle Alluvium overlies the writer's Qu'Appelle Clay and is exposed on the surface in the Qu'Appelle Valley. In Christiansen's section, this unit has a thickness of 30 feet.

Composition.- The Qu'Appelle Alluvium is composed of clay, silt and sand. The clay is interbedded with very fine sand and silt. Organic matter is present in the finer fractions.

Interpretation of the Rocky Lake Section

General statement.- This section was named and described by Christiansen (1961, p. 32-33, p. 67). He interpreted the lower lacustrine unit and the overlying sands and gravels as belonging to or being correlative to the Lower Stratified Drift. This can be clearly seen from his section. He interpreted the till which separates the lower lacustrine unit from the upper lacustrine unit as being Condiean. The upper lacustrine unit has been called the "Regina Clay" (Condie Clay of this report) by Christiansen (1961, p. 33). The upper lacustrine unit is overlain by Condie Till deposited during a small readvance which formed the Rocky Lake Moraine.

Composition.- The basal part of the Lower Stratified Drift, here called the lower lacustrine unit, is composed of clay, silty clay and silt. The lower part of the unit exposed is predominantly silt and grades upward into silty clay and then clay. Locally, the unit contains an abundance of limonite.

The upper lacustrine unit or Condie Clay is calcareous, yellowish-brown to grey, oxidized to unoxidized. This unit also contains limonite.

GEOMORPHOLOGY AND DRAINAGE HISTORY

Pre-lake Topography of the Regina Basin

The presence of two highlands caused an ice flow to follow a long, narrow basin, the Regina Basin, at an elevation of about 2000 feet, part of the Assiniboine River Plain. The upland to the southwest of the Regina Basin is the Missouri Coteau, which is partly a rolling

morainic plain and partly a dissected escarpment (Kupsch, 1958). Elevations of the Coteau range from 2000 to 2800 feet. To the northeast of the Regina Basin lies the Moose Mountain Hills Upland with elevations ranging from 2000 to 2650 feet (Acton et al., 1960). To the southeast the Regina Basin continues as the Souris River Plain; to the northwest the Regina Basin ends abruptly at the south side of the Qu'Appelle Valley.

The floor of the Regina Basin is not smooth or plain-like, but contains numerous kames, washboard moraines, and end moraines. In some localities these land forms protrude through the lacustrine clay; in areas where the lake sediment is thin, particularly near the edges of the basin, minor recessional ridges are visible.

Glacial Lake Moose Jaw Drainage Phase

Before isostatic adjustment began, meltwater which had been dammed in front of the ice drained through the Souris River Spillway. This spillway was the main drainage channel for meltwater off the Weyburn Lobe (Christiansen, 1956, p. 30, Figure 13). However, once the lake was in the Regina Basin, only the water which overflowed the lake drained through the Souris River Spillway. The meltwater from the ice and proglacial areas drained into broad unilateral channels in the Regina Basin and finally through the Souris River Spillway.

Glacial Lake Regina Drainage Phase

The use of the Souris River Spillway was discontinued when isostatic adjustment elevated the outlet. Since glacial till overlies the Regina Clay in the northern part of the basin, the outlet for the Regina Phase is not known. It is assumed, however, that drainage occurred along a spillway which is presently occupied by the Qu'Appelle Valley.

Thunder Creek Channel served two purposes. While Glacial Lake Regina was being formed, Thunder Creek Channel drained the proglacial area to the west of the Regina Basin contributing meltwater to the basin (Christiansen, 1959, p. 55). When Glacial Lake Regina was drained, the channel formed a collecting channel on the lake plain, on which is now superimposed Moose Jaw Creek and possibly the Qu'Appelle Valley east of Moose Jaw and Buffalo Pound Lake. During the subsequent history of Lake Regina meltwater from the west was drained by the South Saskatchewan-Qu'Appelle River systems, thereby leaving the Thunder Creek Channel as a trough on the lake bottom. When Glacial Lake Condie drained, Moose Jaw Creek formed as a collecting channel on part of the partially buried Thunder Creek Channel east of Moose Jaw.

Glacial Lake Regina Beaches.- Beaches belonging to the second lake, Glacial Lake Regina phase, are found only along the northeast shoreline. They are located between Victoria Plain and Kathrintal Colony. The beach ridges vary in length from 1/4 to 3 miles, and in height from 2 to 15 feet. The beach sediment, which was derived from a kame moraine to the east, is composed of fine to coarse sand which is sub-angular to rounded. The mineral content is predominantly quartz (90 to 95 per cent) with the remainder consisting of feldspars, carbonates, and heavy minerals. A small amount of carbonate material is present as a cement in the pore spaces. Four beach series are visible (tp. 17, rge. 18) but they are not continuous. Since they can not be traced for any great distance, they are of no value in determining deformation of strandlines. The differences in elevation of the beaches are very small; at present they parallel the contour lines but in some places contour lines cross the

beaches. Flint (1957, p. 145) held that small beach ridges are commonly associated with receding shorelines built up by sediment left behind in individual storms. The evidence available appears to fit this concept.

Incipient ridges southwest of Baildon are present beneath lacustrine clay. These ridges are not exposed; however, in a road cut (NW 1/4, l.s. 15, sec. 32, tp. 14, rge. 25) a fine to coarse sand, over which is draped lacustrine clay, is similar in mineralogical composition to the beach ridges southeast of Victoria Plain. If these lineaments are beach ridges they would be related stratigraphically to the beach ridges between Victoria Plain and Kathrintal Colony because they are overlain by Condiean sediments.

A strandline, cut in till just above the lacustrine clay, 2 miles south of Sedley, may also belong to the Glacial Lake Regina phase. The strandline consists of a wave cut cliff which is prominent in the field and on aerial photographs and mosaics. It exhibits a local relief of approximately 20 feet; no sands or boulders are visibly associated with it but these may have been buried during the subsequent sedimentation.

Glacial Lake Condie Drainage Phase

Readvance of the Condiean Glacier into the Regina Basin produced another lake, the Condiean Lake which drained through the Qu'Appelle Spillway. Many collecting channels formed on the draining surface of the Condie Plain. The major collecting channel was the Moose Jaw Creek Channel draining the northwestern portion of the lake with Stony Beach and Rocky Lake Channels as its distributaries. Waskana Creek and Boggy Creek Channels formed other important collecting channels, gathering water from the central and northeastern areas. Cottonwood Creek Channel

is subsidiary to Waskana Creek Channel and drained the central region of the lake.

Present Topography of Glacial Lake Condie Plain

Glacial Lake Condie Plain, which forms the surface of the filled-in basin, is also bounded by the Missouri Coteau Upland, the Moose Mountain Hills Upland, the Souris River Plain, and the Qu'Appelle Valley. The lake plain is undulating to very gently undulating. Locally the surface is interrupted by kames, washboard moraines, and end moraines whose relief above the plain is from 5 to 75 feet.

South of the Qu'Appelle Valley, the Condie Moraine interrupts the surface of the land as an arcuate ridge with local relief of 5 to 75 feet. The Rocky Lake Moraine north of the Condie Moraine marks another pause in the retreat of the ice with a ridge 5 to 50 feet above the lacustrine plain.

Glacial Lake Condie Beaches.- The strandline associated with the third lake in the Regina Basin, the Condie phase, can be traced around the basin, but with difficulty. This shoreline occurs in all places 50 feet above the lake clay-till contact except along the northern boundary where the lake was in contact with the continental ice sheet. The delineation of the strandline was accomplished using a variety of evidence. The rate in change of slope was one of the most important criteria used, as beach or lag deposits were absent in nearly all places. Where lag deposits are present, the position of the strandline can be determined with more certainty. Straightness and parallelism of the contour lines on topographic maps were also used as an indicator. Tonal differences and lineaments on aerial photographs and mosaics also aided in defining a

strandline for the Condiean phase. Where the edge of the basin approaches the Missouri Coteau, the shoreline becomes obscured by large alluvial fans from the Coteau face.

Lake Rouleau Drainage Phase

After the Rouleau Basin was formed, Moose Jaw Creek had to lower its base level in order to drain the basin. Degradation was a continuous process for this channel because the stream bottom of the Qu'Appelle Valley was consistently being lowered. When the nickpoint of the channel reached the basin, complete and rapid drainage took place. Later, intermittent streams found their way to Moose Jaw Creek. It should be noted that Moose Jaw Creek had to adjust its course after isosatic adjustment had taken place. This is shown by the offset of Moose Jaw Creek in Township 15, Ranges 24 and 25 from its original course.

Topography of Lake Rouleau Plain

In the west-central portion, the Regina Basin is interrupted by a small depression, the Rouleau Basin. The Lake Rouleau Plain is 25 feet lower in elevation and completely surrounded by the undulating Condie Plain. The surface of the Rouleau Plain is extremely flat, consequently surface drainage is very poor causing large scale flooding during the summer months.

Lake Rouleau Strandline.- The Rouleau Basin has 85 miles of well defined shoreline. A 25 foot scarp, which is well shown on aerial photographs and mosaics, can be clearly seen in the field and marks the position of the shoreline. It is clearly a faulting scarp rather than a wave cut cliff.

Qu'Appelle Valley Drainage Phase

During the retreat of the continental ice sheet from central Canada, the Qu'Appelle River was part of a vast network draining the southern parts of Alberta, Saskatchewan, and Manitoba. The South Saskatchewan, Qu'Appelle, and Assiniboine Rivers formed the main artery through which water flowed from west to east into Glacial Lake Agassiz. Once the ice sheet had retreated far enough to expose a lower outlet, the South Saskatchewan continued its course northward, capturing the drainage from the Qu'Appelle River. Because of this, the Qu'Appelle Valley now contains a misfit stream.

The initial channel of the Qu'Appelle River in the area was in all probability a small valley which was part of Thunder Creek Channel when Glacial Lake Regina was drained. The readvance partially filled the valley, and the ice marginal channel west of Buffalo Pound Lake merged with the partially buried channel forming Qu'Appelle Valley. It is evident from the number of terraces preserved on the inside of slip-off slopes that the development of the Qu'Appelle Valley was very gradual. Increased activity because of isostasy and changing base level caused the river to rejuvenate itself in an effort to attain an equilibrium slope.

Geomorphology of the Qu'Appelle Valley

The geomorphology of the Qu'Appelle River Valley is typical of a meltwater channel in that its presence is not noticed when it is approached from the side. The present misfit stream is in a valley which is one mile wide at the bottom and is 300 to 400 feet deep. Valley fill is in the order of 100 to 150 feet accounting for the flatness of the bottom. The valley walls are very steep but become gentler in areas where bedrock

exposures cause slumping. The Qu'Appelle Valley has many tributaries such as Moose Jaw Creek, Cottonwood Creek, Waskana Creek, and Boggy Creek. Their profile is "V" shaped and in most places they do not contain valley fill.

Faulting

Since Warren (in Fraser et al., 1935, p. 61-62) first noted stratigraphic discontinuities of Mesozoic strata in the Regina Basin along the Missouri Coteau, several other authors (Kupsch and Wild, 1958; and Haites, 1959) have advanced various ideas as to the reason for the structural anomalies.

The two theories most commonly held are (1) salt-solution collapse and (2) tectonic faulting. Both papers mentioned above hold the latter thesis but do not completely discount the salt-solution collapse hypothesis. The most convincing piece of evidence cited by Kupsch (1957) and Kupsch and Wild (1958) for tectonic faulting is the earthquake which took place on May 15, 1909. The position of the epicenter of this earthquake was 105° W. Long., 50° N. Lat. Kupsch and Wild (1958) note that the epicenter is almost superimposed on their A_2 lineament. Further, Haites (1959) projected his Truax fault through the epicenter after defining it by three wells with known displaced marker beds. Tectonic activity is also suggested by the presence of a water well, approximately 2000 feet deep in the City of Moose Jaw, producing ground water at a temperature of around 80° F. This is about 30° to 40° higher than the average temperature of ground water from this depth.

The writer holds that the Rouleau Basin was formed as a result of faulting. Haites (1959, p. 170) cited Moose Jaw Creek as the best defined

lineament in the area and accounted for the Missouri Coteau as a fault-line scarp. He stated, further, that the Missouri Coteau was formed by transcurrent faulting (Haites, 1959, p. 175). In regard to the salt-solution collapse theory, Haites (1959, p. 171) felt that the removal of hundreds of feet of salt with subsequent collapse would manifest itself on the surface in the form of a depression and fractures. Further, he felt that a transcurrent fault could provide the channel along which solvent would travel. The present writer suggests that the Rouleau Basin was formed as a result of an area of salt-solution collapse which has as its footwall, on the northeast side, the face of a transcurrent fault along which solvents were able to move. The topography of the bedrock surface as presented by Christiansen (1961, Plate 2) does not show this anomalous depression. However, if the bedrock surface is recontoured with the above suggestion in mind, the outline of the Rouleau Basin can be seen (Figure 2). The result of removing several hundred feet of salt has been translated to the surface by a displacement of some 40 feet. It is thought that the collapse of the strata was triggered by adjustment along the transcurrent fault.

Isostasy

Johnston and Wickenden (1930, p. 47) were the first to notice that relative vertical movement of the lake plain had occurred. However, they were not able to arrive at any conclusions as to isobase positions because of the lack of good beaches or strandlines. They did estimate that approximately 75 feet of differential uplift had occurred. Christiansen (1961, p. 18) concurred but showed from field evidence that the differential uplift was about 100 feet.

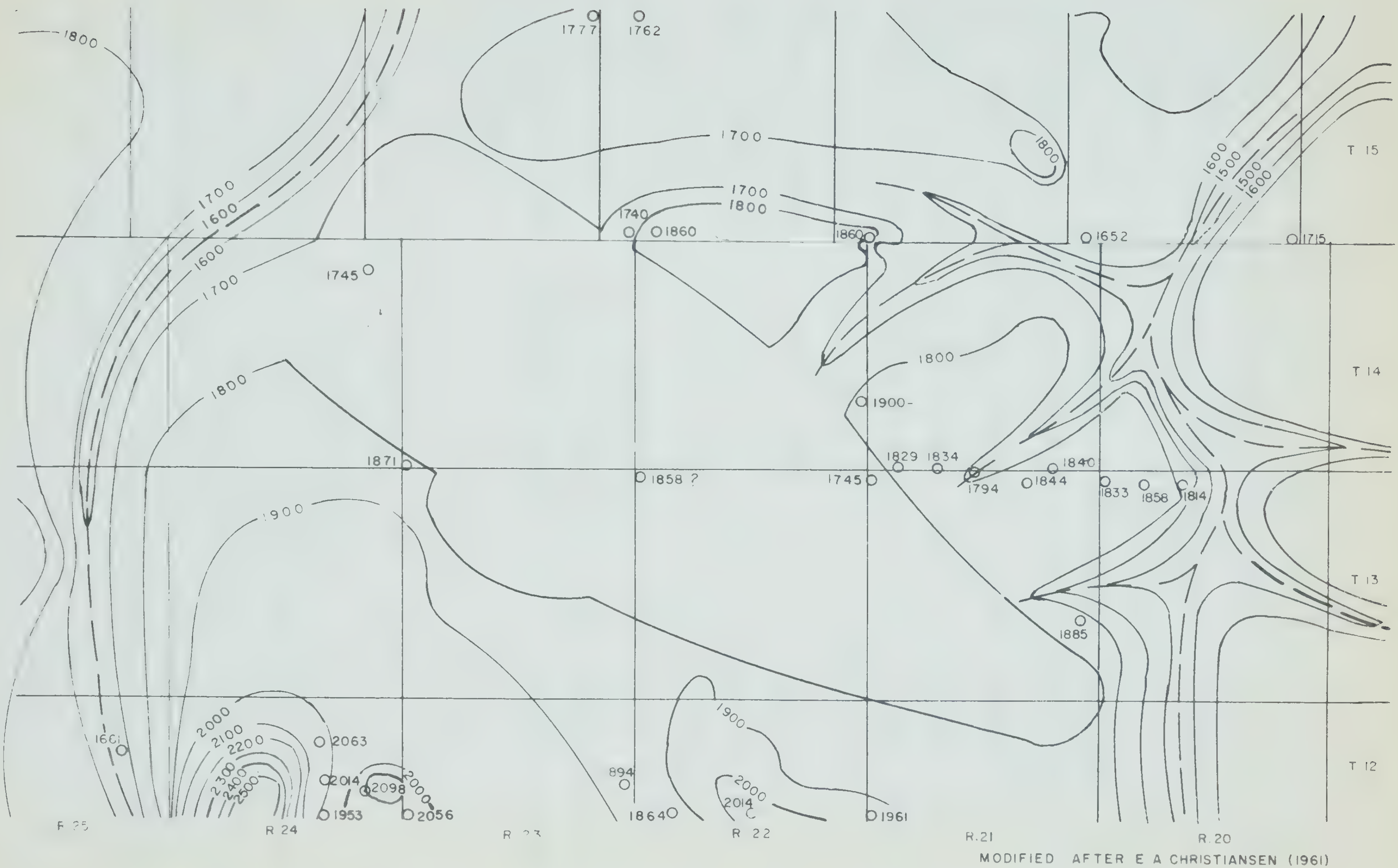

FIGURE 2.—BEDROCK TOPOGRAPHY AND FAULTING, ROULEAU BASIN AREA

A detailed investigation indicates that there was a vertical difference of 50 feet in elevation between lake clay-till contact and the strandline produced during the Condie phase. By using aerial photographs and mosaics as well as the soils map, the boundary between the lake clay and the till was accurately plotted. Assuming that the strandline was 50 feet higher than this contact, except in the northern boundary, strandline profiles (Figure 3) were constructed to show the positions of the isobases (Figure 4). It was found by this method that 150 feet of differential uplift had occurred along five main hinges. The Souris River outlet at the present time is at an elevation of 1900 feet, while differential uplift has raised the Condie Plain to 2050 feet in the northern region. Position and attitude of the isobases are given in Figure 4.

Johnston (1946) indicates that the history of isostatic adjustment may be complicated by the presence of faults. It is known that faults are present in the Regina Basin, therefore the isobases proposed in this report are tentative. A much more complete study is required to clear up many discrepancies.

MINERALOGY

General Statement

Heavy minerals were used to study the composition of the parent rock types, and a study of the clay minerals aided in the determination of sedimentary rock units over which the continental ice sheet moved. Authigenic minerals were used to interpret depositional and post-deposition history of the clays and silts.

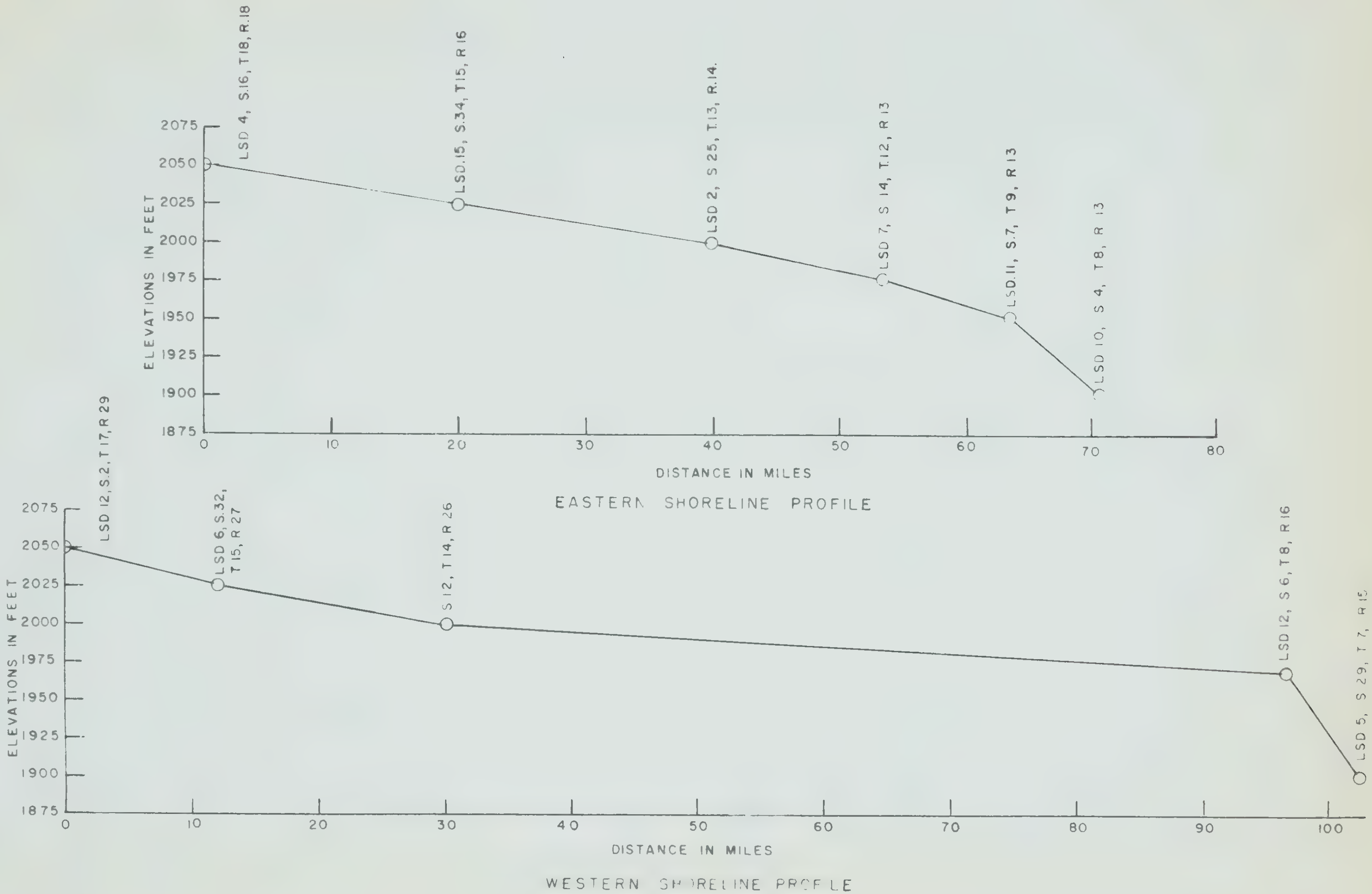

FIGURE 3.—SHORELINE PROFILES IN THE REGINA BASIN

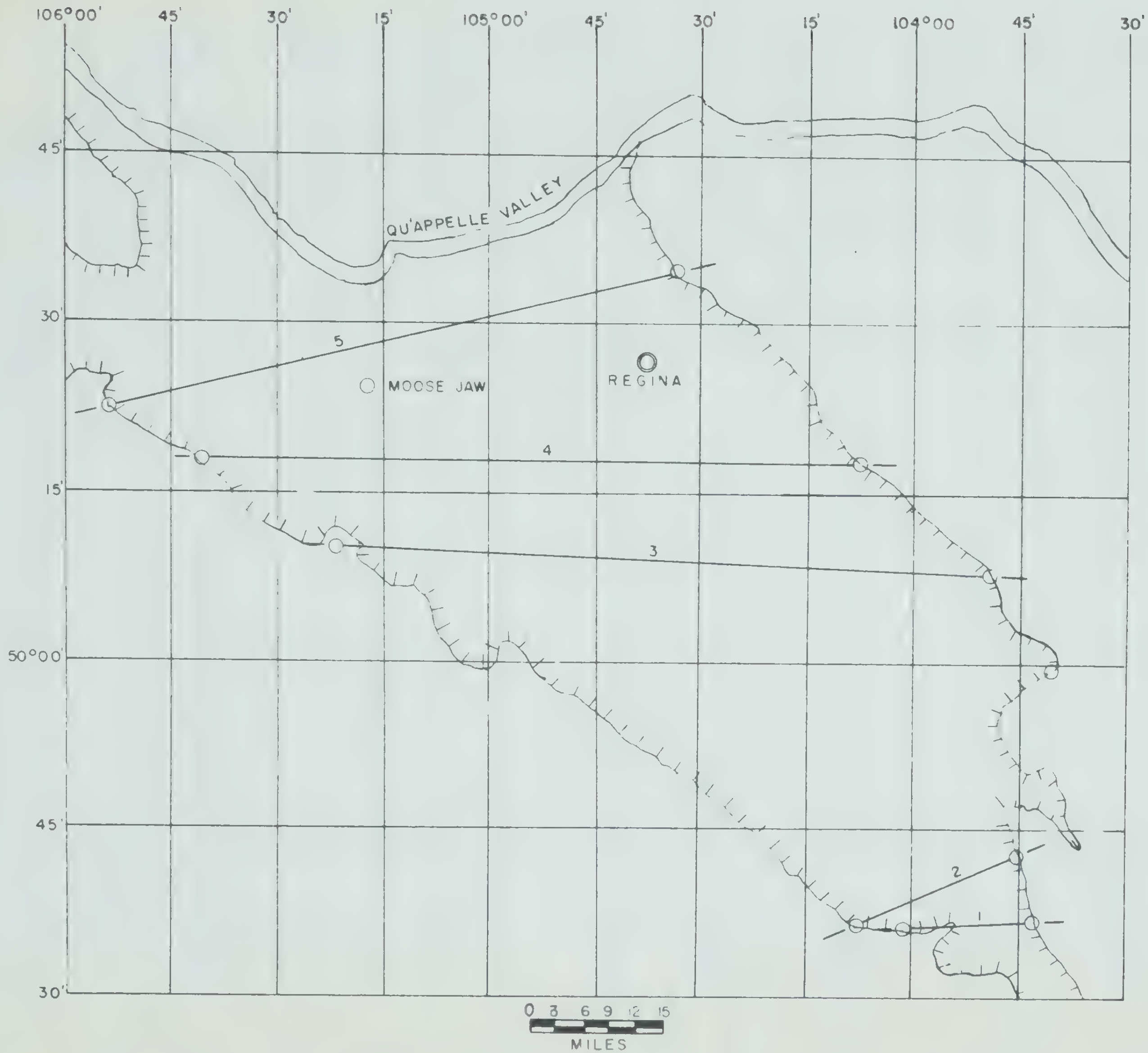

FIGURE 4.—ISOBASES IN THE REGINA BASIN

Heavy Minerals

Samples were dried, weighed, and disintegrated before the silts were separated from the clays by decantation. The light and heavy fractions were separated using tetrabromoethane (s.g. 2.94). All size fractions of the heavy minerals were separated into fractions of varying magnetic susceptability by the use of a magnetic separator. Separates were mounted in aroclor (n=1.66).

The opaque heavy minerals include the usual assemblage of hematite, leucoxene, limonite, and magnetite. They were not studied in any detail.

A brief description of each major non-opaque heavy mineral species follows (Figure 5):

Apatite.— Colorless under the binocular microscope; characterized by its low birefringence and its uniaxial negative figure. This mineral species is fairly abundant in the non-magnetic fraction. The grains are well rounded, some etching may be seen.

Biotite.— Brown to yellowish brown biotite is present in the low amperage magnetic fraction. The grains are subhedral, basal cleavage predominates. Its habit allowed it to be readily winnowed from the sediment, which are biotite deficient.

Clinozoisite.- Colorless under the binocular microscope, it is common mineral constituent in the non-magnetic fraction. The grains are anhedral, edges and corners are sharp and ragged, surfaces are etched. Inclusions are common.

Garnet.- The almandite variety, pink to reddish pink in colour, is an abundant mineral constituent of the lacustrine sediment. Garnet is the

most common isotropic mineral. The grains are not well rounded, corners are sharp, surfaces show a high degree of conchoidal fracturing. The surface of the grains are seldom pitted or show percussion marks. Inclusions are rare to common.

Hornblende.- Green to blue green hornblende is a very common mineral constituent of the low amperage magnetic fraction. Hornblende is the most abundant, coloured, heavy mineral. The grains are subhedral, cleavage faces are common.

Rutile.- This mineral is a very minor constituent of the heavy mineral fraction. The grains are reddish-brown, striated, and angular. They are readily recognizable by their colour and extreme refractive index.

Staurolite.- This species was identified as a very rare constituent in the samples. The grains are subhedral, have a good 010 cleavage; inclusions are common, imparting a sieve structure; colour of the mineral is golden yellowish brown.

Zircon.- The zircons from the samples were all colourless. Extensively fissured zoned zircons are common in which the crystal habit is prismatic with pyramidal terminations. Unzoned inclusion rich zircons are also common, these are subhedral, clear, and unfissured.

Others.- Spinel (picotite), tourmaline, and monazite were rarely found in some samples.

Clay Minerals

General statement.- The clay fractions from the samples used for heavy mineral analysis were used for studying the clay minerals. Three samples of the Condie Clay, one of the Rouleau Clay and one of the Qu'Appelle Clay were X-rayed.

Montmorillonite.- The only expandable (2:1) three layer silicate present in the samples was montmorillonite. When the clays were X-rayed (after treatment with sodium hexametaphosphate) they gave a broad peak at 12.62 Å and after glycolation the peak was narrower and had shifted to 17.52 Å.

Illite.- The illite peak occurred at 10 Å when X-rayed after treatment with sodium hexametaphosphate and ethylene glycol. In general, the peaks were narrow and very sharp.

Kaolinite.- When the samples were treated with sodium hexametaphosphate and X-ray, a prominent narrow peak occurred at 7.1 Å; this did not shift after glycolation. However, when the samples were heated to 475° C the peak was destroyed indicating the presence of a kaolinite (Warshaw and Roy, 1961).

Interpretation.- From work done on clays by Christiansen from the Moose Mountain, Swift Current and Qu'Appelle Valley areas it appears that the source for the clay minerals, particularly montmorillonite, is the Upper Cretaceous bedrock. Illite and kaolinite could possibly have been derived from the Precambrian Shield. A local source for the kaolinite could be the Whitemud Formation.

Authigenic Minerals

General remarks.- Calcite and gypsum (selenite) were formed during and after the deposition of the lacustrine clays and silts. Leaching of sulphates and carbonates from the rock flour supplied the main chemical components for their growth.

Growth in voids.- Plant roots penetrated the lake clay during the dry intervals, and the voids which remained after their decay provided

channels by which interstitial solutions could move. These solutions were commonly saturated with sulphates, and gypsum was deposited.

Selenite crystals are present in a core 27 feet from the surface of the Regina Basin. The major growth of selenite crystals is in a horizontal position. Microscopic examination of the crystals indicates that they contain inclusions of clay and organic particles. Carbonaceous spots representing rootlets are visible on a horizontal section of the core. In some places, selenite crystals have grown in the void left by the rootlet and show a ring of organic material about the external edges of the crystals. This would indicate that the force of crystallization was sufficient to displace the clay and silt particles. Other examples of this type of crystallization occur at depths of 8 and 15 feet below the surface (Plate 1, Figure 1).

Twinned selenite in clays.- Some selenite crystals occur as discs with greatest thickness in the middle (Plate I, Figure 2), thus differing greatly from the more common "Swallow-tail type" generally seen on exposures of marine shale. In some of the crystals, interpenetrating twins are located above and below the area of greatest thickness (Plate I, Figure 3). The crystallography is as follows: The "b" axis is in the plane of maximum diameter normal to the plane (010) of perfect cleavage (Plate I, Figure 4). The "c" axis is perpendicular to the "b" axis, and the (100) plane is parallel to it, and forms the composition plane for the twin. The attitude of the "a" axis varies with its location; in the disc it is parallel to the (001) cleavage direction and makes a "beta" angle of 118° 23' to the "c" axis. The position of the (001) cleavage in

the disc in relation to its position in the interpenetrating twin forms the "herring bone" pattern of the common "swallow tail type" twins (Plate I, Figure 5).

Selenite crystals on the surface of an exposure exhibit good crystal form, the faces generally can be determined fairly easily, and intergrowths may occur at any angle to the main body of the larger crystal. The twin described previously apparently did not have this freedom to grow in any direction. The orientation of the selenite disc in the clay clearly shows that the longer axis, the "b" axis, grew parallel to the bedding in the direction of minimum principal stress whereas the shorter axes grew in the direction of maximum principal stress at an angle to bedding. Reorientation of the minimum principal stress direction due to over riding ice, caused a relocation of growth position, allowing the interpenetrating growths to expand. It should be further noted that the interpenetrating twins penetrate the disc, but only began to grow as projections after deformation of the strata. Resorption of the first formed crystal occurred during later growth. Selenite crystals of this description were located in an exposure 1/4 mile north of Chamberlain in the north bluff of the Arm River Channel on the east boundary of Section 9, Township 22, Range 26. These disc-like selenite crystals also were noted in fractures and along bedding planes beneath an organic zone in the Rouleau Terrace.

<u>Aggregate growths in clays</u>.- An aggregate or cluster of disc-like selenite crystals (Plate I, Figures 6 and 7) is thought to have formed in a cavity. The aggregate is a spherical cluster of radiating and impinging disc-like crystals with a hollow central region filled by small unorientated granules of selenite. Growth of the crystals has been outward into the clay medium.

A loose cluster of well-formed selenite crystals occurs 1 to 2 inches beneath an organic zone in the Rouleau Terrace (1600 feet north SW corner sec. 27, tp. 15, rge. 24). The five crystals (Plate 2, Figures 1 and 2) have grown independently about a common center controlled by the position of the "b" axis. Because the weight of overburden (1 to 2 inches) was negligible, the crystals were free to grow in any direction. However, crystals which grew after the terrace was covered, are disc-like and parallel to joint and bedding planes.

Secondary leaching.- After formation of the organic zone in the Rouleau Terrace, humic acids percolated downward through the clay, leaching soluble salts. The upper surface of the crystals below the organic zone have become deeply pitted (Plate 2, Figures 3 and 4) and in some places solution tubes have formed. After burial of the terrace, growth on the pitted surface resumed but secondary growths are small because there was little soluble sulphates left in the clay.

Post glacial leaching has occurred in the top 2 feet of sediment in the Regina Basin as indicated by absence of carbonates and sulphates.

Allogenic Minerals

Waskana Creek Ash.- The Waskana Creek ash is purplish grey in colour but may appear grey or white on weathered surface. Mechanical analysis indicates the average grade size is coarse silt with 65.8 per cent of the particles having a diameter less than 74 microns. The median diameter was found to be 86 microns.

The index of refraction of the glass shards is 1.500, indicating that they came from a magma of acid composition with 70-75 per cent silica (George, 1924, p. 365).

The volcanic ash is almost entirely glass with very minor amounts of K-feldspar present. As far as can be determined, no contamination of the deposit occurred during deposition.

GEOCHEMISTRY

General Statement

Lacustrine clay samples from two test holes were analyzed for sulphates and carbonates. One test hole (NE corner, sec. 30, tp. 14, rge. 23) covered the sequence Moose Jaw Clay, Regina Clay, Condie Clay, and Rouleau Clay, while the other test hole (SE corner, sec. 14, tp. 14, rge. 23) covered only the Rouleau Clay. Sulphates and carbonates were determined to find out whether or not extensive periods of evaporation or leaching had occurred in the Regina Basin.

Regina Basin

Analyses indicate a variable range of from 0.42 to 7.85 per cent calcium sulphate in the Regina Basin (Figure 6). The reduced calcium sulphate content at 25 and 19 feet is interpreted as representing the exposed surfaces after Lakes Moose Jaw and Regina drained. Changes in the amount of sediment brought into the basin and the depositional environment are thought to have caused the variability in the amount of sulphate deposited in the sediment. The high sulphate content at the 15 foot zone may represent a period of evaporation when the ice front retreated during Condiean time prior to its readvance to form the Rocky Lake Moraine.

The source of the sulphates is shale of the Bearpaw Formation which was incorporated into the ice and later deposited as drift.

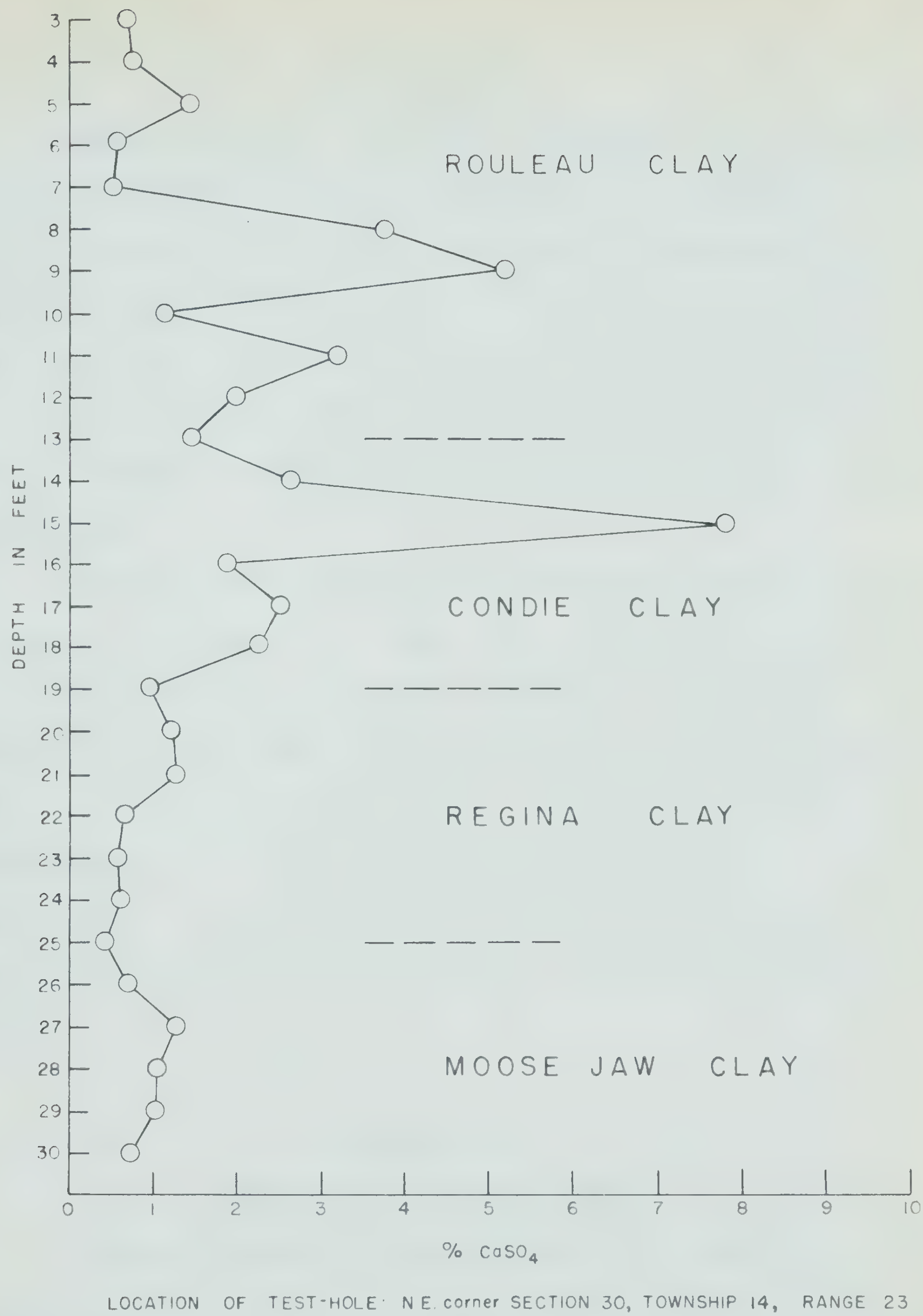

FIGURE 6 — DISTRIBUTION OF SULPHATES IN THE REGINA BASIN

Rouleau Basin

Lake Rouleau was a remnant of Glacial Lake Condie. There was water in the basin from the time the Condiean lake drained until Lake Rouleau drained, with continuous deposition of sediment between the two phases. Chemical changes in sediments occurred when the chemical environment of the lake changed. Sediments deposited in the Rouleau Basin were derived from the Regina and Condie Clays exposed on the edges of the basin. Sulphates and carbonates in solution were obtained by leaching of these clays.

Figures 6 and 7 indicate a zone of high sulphate and carbonate content in the Rouleau Basin. This zone is interpreted as representing a time when evaporation took place. Inspection of the sediment in the zone shows that the gypsum is dispersed through the clay-sized sediment indicating contemporaneous deposition. The water in Lake Rouleau was never more than 40 feet deep and probably averaged 25 feet. The ice had retreated far to the north and consequently wind activity and extreme temperatures were not factors influencing the chemical environment of the lake.

SEDIMENTATION

Deposition in the Regina Basin

Sediment deposited in the Regina Basin was derived from the melting glacier to the north. An X-ray diffraction pattern of the sediment shows it to be mainly rock flour. Igneous, metamorphic, and sedimentary limestones and shales incorporated into the glacial ice were

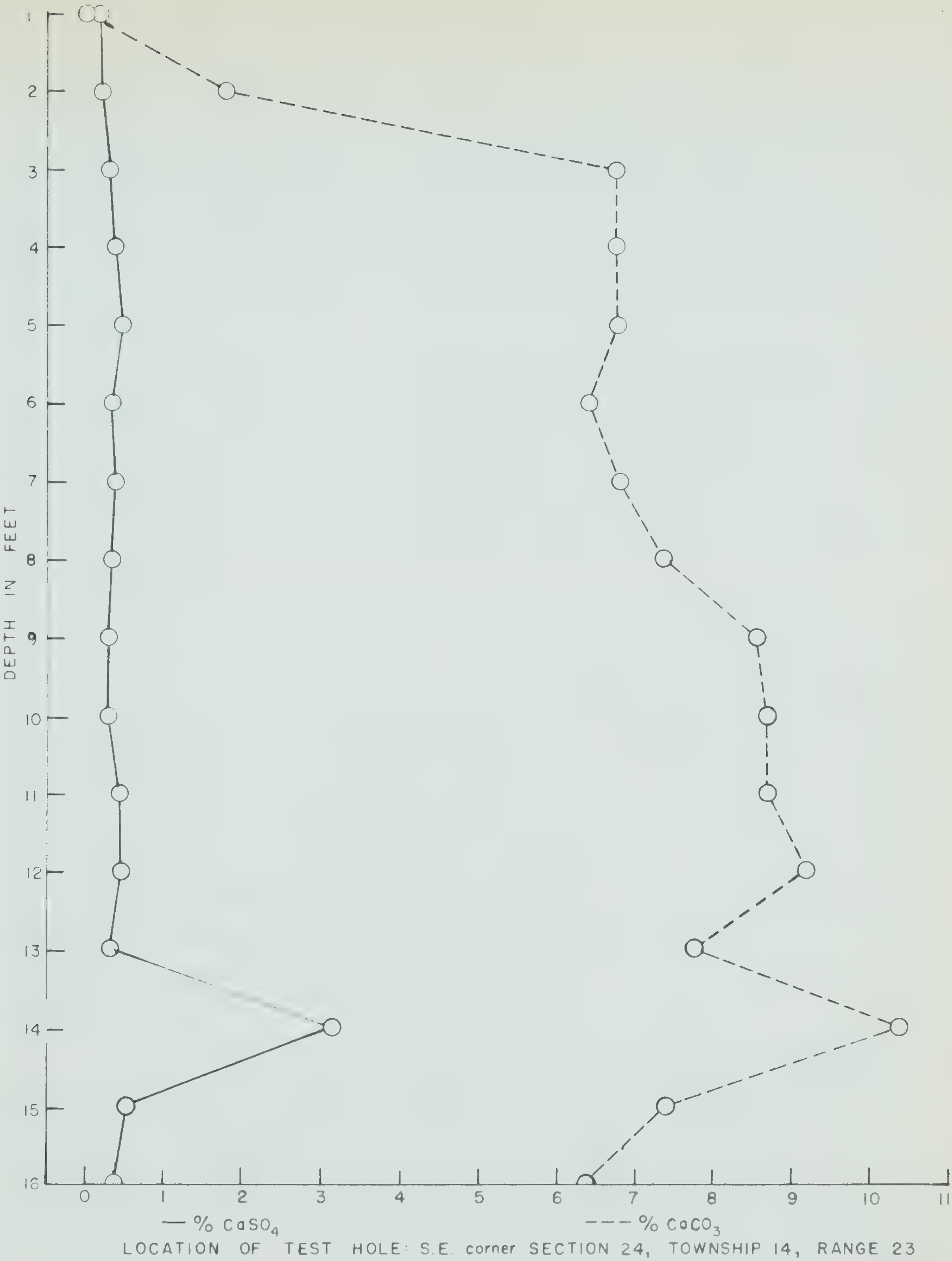

FIGURE 7 — DISTRIBUTION OF SULPHATES AND CARBONATES IN THE ROULEAU BASIN

sorted by meltwater streams on the ice surface and discharged into the lake in front of the glacier. Englacial drift was rafted into the lake by icebergs. Periodic settling of the coarser particles during springs and summers and the finer particles during autumns and winters gave rise to varved clays.

The basal part of the lacustrine sediment contains many granules and pebbles. As the glacier retreated farther north, silts and clays in suspension were deposited over the coarser basal lacustrine unit. Occasional icebergs dropped coarse material into the more homogeneous clay-sized sediment.

It is known that as Lake Moose Jaw formed the ice retreated from the edge of the Regina Basin as a lobe forming unilateral channels which emptied into the Souris River Spillway. The swiftness of the streams in the channels transported all the coarse material, generally deposited when the ice front retreats, down stream, leaving a bare till or bedrock surface on which beaches could not readily form. The only coarse sediment deposited as beaches was derived by the winnowing action of wave currents on exposed till and kame-eskerine complexes.

Varved clays are scarce to absent in the lacustrine sediments of the Regina Basin. The distribution of varves in the basin is restricted to relatively deep, quiet water in front of the ice. It is thought that had the water in the lake been quiet, varves probably would have been preserved. The winds during late Wisconsin time in the Regina Area are thought to have been fairly strong, coming off the glacier from the west northwest. If the winds were sufficiently strong to produce

relatively high waves, then varves which were formed during the winter months would be destroyed in the spring and summer months.

Contorted varves are exposed in the west side of Waskana Creek Valley, 1/4 mile south of the northeast corner of Section 29, Township 18, Range 21 and also in the south bluff of a small creek 300 feet north, 750 feet west of the southeast corner of Section 8, Township 13, Range 15.

After the deposition and formation of the Condie Moraine, the glacier front retreated approximately to the Qu'Appelle Valley. During the halt which ensued, vast quantities of meltwater poured off the ice to form a delta in Glacial Lake Condie. The delta sediment is silty sand with little or no clay which was deposited farther out in the basin. A certain amount of interdigitation occurs between the silt of the delta and the lacustrine sediment. Delta sediment is exposed in the Cottonwood Creek section described by Christiansen (1961, p. 65-67).

A study of heavy minerals indicates that the source of sediment for the Regina Basin on the eastern side was from the glacier to the north. The samples studied were from test holes F, G, and L (Christiansen, 1961, p. 36). An attempt was made to pick samples that were at the same horizon. Of the eight mineral species studied, six were found to diminish in quantity from the north to the south. Clinozoisite, biotite, zircon, and hornblende were the minerals most affected, with clinozoisite decreasing most notably (Figure 5). The heavy mineral suite studied from a test hole (SE Corner, sec. 32, tp. 13, rge. 23) of Condie Clay indicates an influx of heavy minerals which are not present in the other suites previously mentioned. Kyanite, monazite, and staurolite appeared as additional minerals and rutile was in greater abundance. Fraser

Mineral	Test Hole F*	Test Hole G*	Test Hole L*	Test Hole 6**
Apatite	A	A	A	A
Biotite	C	C	R	A
Clinozoisite	A	C		A
Garnet	A	A	A	A
Hornblende	A	A	C	A
Kyanite				C
Monazite				C
Rutile	R	R	VR	C
Spinel		VR		
Staurolite	VR	VR		C
Tourmaline		VR		
Zircon	A	A	R	A

* See Christiansen 1961, p. 36. ** SE corner sec. 14, tp. 14, rge. 23.
A greater than 50 grains, C 5-50 grains, R 2-5 grains, VR less than 2 grains out of 500 grains.

FIGURE 5.- HEAVY MINERALS PRESENT IN CLAYS FROM REGINA BASIN

(in Fraser et al., 1935, p. 93) reported that kyanite and staurolite were found only in the Whitemud and Lower Ravenscrag Formations. These two formations are exposed in the Coteau face and, therefore, could have contributed to the sediment on the western side of the Regina Basin.

The silty sediment northeast and east of the Keeler Upland was deposited during the Condiean maximum. The silt was deposited further from the ice than the sand, and was augmented by the entry of meltwater from the northwest into the basin. Lacustrine silt interfingers with the clay at its maximum extent.

Lacustrine silt and clay is exposed in a road cut 1/4 mile north of Chamberlain in the north bluff of the Arm River Channel on the east

boundary of Section 9, Township 22, Range 26. The clay and silt is oxidized, contorted and overlain by glacial till. It is possible that this unit represents the northern extension of the Regina Clay which was subsequently overridden by the Condiean ice sheet and covered by Condie Till. Contortions of the clay and attitudes of selenite crystals indicate that the lacustrine unit was overridden by active ice.

A volcanic ash deposit, the Waskana Creek Ash (Christiansen, 1961, p. 32), is up to 4 inches thick with a limited lateral extent. The Waskana Ash is associated with lacustrine clay, but, both units pinch out laterally into till. The ash is underlain by a lens of sand and clay which has been interpreted as a pond in which the volcanic ash and lake sediment deposited during the Condie Phase. Christiansen (1961, p. 34) interpreted the deposition of the ash as being on dead-ice because of the contorted nature of the lake clay and also because of the gradational contact between the clay and the clay-poor till. Contortion of the varves could also be attributed to hydro-plastic flowage when the silt bands became supersaturated.

A study of stabilized dunes by the writer in Saskatchewan and adjoining areas with Dr. W.O. Kupsch, indicated that the predominant wind direction in this area was from the west-southwest. It is possible to postulate a source for the ash from north-central Washington. Mineralogically the ash is similar to the Galata Ash of Montana and southern Alberta described by Horberg _et al_. (1955) which is interpreted to have been from this source. The writer does not wish to imply that the two ash deposits are correlative.

Deposition in the Rouleau Basin

The formation of the Rouleau Basin by faulting caused unstable scarps to be formed which quickly became reduced to gently sloping strandlines. The hydroplastic Regina and Condie Clays became unstable when saturated, thereby causing slumping of the clays into the basin, producing turbidity currents. The turbidity currents increased the sedimentation rate in the middle of the basin.

Very little reworking of Regina and Condie Clay took place in the immediate vicinity of the marginal slumping. Although the pores were saturated with water, little regional leaching of the sediment took place; rather, sulphates and carbonates became localized in the pore spaces.

Within the basin, there was a marked change in the chemical environment of the water. Reduction of the previously oxidized Regina and Condiean sediments and leaching of sulphates and carbonates occurred. An incipient evaporite deposit was formed when total evaporation of the water took place during deposition of the Rouleau Clay. Incorporated into the sediment during this period were plant and animal remains. Ostracods became very prominent once the chemical environment had changed.

Christiansen (1961, p. 38) held that the Rouleau Clay was derived from the Missouri Coteau because of the colour of the bedrock in the escarpment of the Coteau. Some Mesozoic sediment may have been brought into the Rouleau Basin by Avonlea Creek and smaller tributary streams. Byers (1959, p. 3) gave the colours of the various members of the Upper Cretaceous formations as being predominantly yellow to brown, with blue to grey colour prevalent in the Bearpaw Formation. The latter formation is barely exposed in the Coteau face but forms the parent material for most of the

glacial till in Saskatchewan. The Regina and Condie Clays should contain as much Bearpaw as the Rouleau Clay. The Regina and Condie Clays are brown in colour due to oxidation. The Rouleau Clay is predominantly reworked Condie Clay, the grey colour of the Rouleau Clay is related to the reducing environment in which it was deposited. Relative amounts of ferrous and ferric iron associated with the Regina, Condie and the Rouleau Clays account for the colour differences noted.

Deposition in the Qu'Appelle Valley

Christiansen (1961, p. 38, 39) divided the sediments in the Qu'Appelle Valley into three distinct units: the Lower Stratified Drift, the Regina Clay and the Qu'Appelle Alluvium. He based his interpretations in part on one driller's log and two sample descriptions.

The sediments in the Qu'Appelle Valley were deposited long after the Regina Basin had been drained. The lower stratified unit as described by Christiansen is part of the stream bed deposited during the final stages of degradation of the South Saskatchewan-Qu'Appelle-Assiniboine River systems.

The aggradational phase which followed the period of degradation, was accelerated by several means. Large alluvial fans were formed at the mouths of tributary streams and dammed the water in the valleys. Local areas where the valleys had cut through the marine shales of the Bearpaw Formation became unstable and slumped into the valleys. The flow of water was insufficient to completely remove these dams and large bodies of water were formed. At about the time the lakes silted up, the northern outlet for the Saskatchewan River was uncovered causing the South Saskatchewan

River to capture the Qu'Appelle. Subsequent sedimentation in the Qu'Appelle Valley by the stream and its tributaries deposited the Qu'Appelle Alluvium as described by Christiansen (1960, p. 22; 1961, p. 39).

It is interesting to note that both the middle and upper units in the Qu'Appelle Valley contain a rich microfaunal assemblage. A distinct break marked by the absence of microfauna occurs 30 feet from the surface in the Qu'Appelle Valley. The Regina Clay contains no microfauna, and therefore the middle unit described by Christiansen is probably not Regina Clay.

PALAEONTOLOGY

Phylum Vertebrata

General Statement

Vertebrate fossils were found in an organic zone 1/4 to 1/2 inch thick and 10 feet long in glacial drift. The organic remains are in a caustobiolith which rests conformably on alluvial clay derived from the Rouleau Basin and deposited as the bed of Moose Jaw Creek. The present Moose Jaw Creek has cut its base level lower, exposing the old stream bottom in section as a terrace, Rouleau Terrace. Mass wasting of the very plastic Regina and Condie Clays has covered the caustobiolith except in a few places.

The vertebrate material collected consists of one skull and one dentary of a meadow vole, *Microtus pennsylvanicus* (Ord), plus an assortment of limbs, ribs, and vertebrae. The mouse *Peromyscus* was represented by an incomplete set of molar teeth plus assorted limbs and vertebrae. The skeletons of the two specimens were not complete and had evidently been

preyed upon by some animal or bird. Besides the two vertebrates, fern? sporangia and undifferentiated plant material made up the bulk of the organic bed (Plate 2, Figure 5; Plate 3, Figures 1 to 6).

The organic bed lies 6 feet above the present bottom of Moose Jaw Creek in the north bluff of the valley. At this point, the valley is 35 feet deep, approximately 1600 feet north of the southwest corner of Section 27, Township 15, Range 24.

Regional Distribution

Hibbard (1956, *in* Flint, 1957, p. 461) reports *Microtus pennsylvanicus* (Ord) as having been found in Illinoian, Sangamonian, and Wisconsinan sediment. The Illinoian fauna was collected near Berends, Oklahoma; the Sangamonian fauna from Jinglebob and Rezabek, Kansas; the Wisconsinan fauna from Frankstown Cave, Pennsylvania and Jones Ranch, Kansas. The species is very common at the present time in Saskatchewan (B. McCorkquodale, personal communication) and Alberta (Dr. W. Fuller, personal communication).

Peromyscus could not be identified specifically because the skeleton was not complete, therefore, its regional distribution is not known. Fuller, (personal communication) who made the identifications, commented that the specimen could either be *P. maniculatus*, *P. leucopus*, or *Reithrodontomys*. He commented further that *P. maniculatus* is a very common mouse in Western Canada at the present time, whereas the other two are extremely rare.

The specimens are deposited in the Geological Museum, University of Saskatchewan.

Phylum Mollusca

General

The gastropods and pelecypods are rather rare. The only section which revealed a high number of molluscs was the Qu'Appelle Valley. Because of their rarity, the specimens are not described.

Ecology

Small fresh water molluscs require an aqueous environment with only a little water movement and plenty of vegetation for survival. If the vegetation is scant, the animals can obtain some of their food from the water in motion. Since they are predominantly vegetarians, the bottoms must be muddy so water plants can grow. Some of the larger forms like *Valvata tricarinata* (Say) do inhabit streams which have fairly strong currents. They cling to the plants, eating them and also receiving some food directly from phyto-plankton in the water.

Local Distribution

Valvata tricarinata (Say) was found to be concentrated in a silty clay unit 99 feet above the Bearpaw Formation in the Qu'Appelle Valley section (Figure 9), and occurs sporadically through the remainder of the section. This species did not occur in the Rouleau Basin or the Rocky Lake sections.

Gyraulus cyclostomus Baker is rare. The species is concentrated and confined to the basal silty unit of the lower lacustrine unit of the Rocky Lake section (Figure 8). This species occurs very rarely in the Qu'Appelle Valley section (Figure 9) but does not show up in the Rouleau Basin section.

Stratigraphic unit	Lithology	Sample number	*Gyraulus cyclostomus*	*Pisidium* cf. *superius*	*Gastropoda* spp	*Cypridopsis vidua*	*Eucandona caudata*	*Eucandona swaini*	*Ilyocypris bradyi*	*Cytherissa lacustris*	*Limnocythere* sp C	*Limnocythere* sp D	*Limnocythere* sp E	*Limnocythere* sp F	*Limnocythere* sp G
Upper Lacustrine Unit — Condie Clay	Clay	1						VC			R	R			
	Clay	2						VC				C	R		
	Clay	3						A		R	C	VC			
	Clay	4						R		R	R	C			
	Clay	5						R		R	C	VC			
	Clay	6						R			R	VC			
	Clay	7						R			R	R			
	Drift (till)	8								R		A			
Lower Lacustrine Unit — Qu'Appelle Stratified Drift	Silty clay	1		R	R			A			C				R
	Silty clay	2			R	R		A			A				
	Silty clay	3						A		R	R				
	Silty clay	4						A		R					
	Silty clay	5						A			VC			R	
	Silty clay	6						A		VC	C			R	
	Silty clay	7						A			A			A	
	Silty clay	8	R	C				A			A			A	A
	Silty clay	9	VC	VC	R		R	A			A			A	A
	Silty clay	10	VC	A				A	R		A			A	A

SAMPLED AT 1 FOOT INTERVALS

A ABUNDANT

VC VERY COMMON

C COMMON

R RARE

CLAY

SILTY CLAY

DRIFT (TILL)

FIGURE 8 — DISTRIBUTION OF MOLLUSCS AND OSTRACODS, ROCKY LAKE SECTION

LITHOLOGY	SAMPLE NUMBER (DEPTH IN FEET)	*VALVATA TRICARINATA*	*GYRAULUS CYCLOSTOMUS*	*PISIDIUM* CF *SUPERIUS*	FERN? SPORANGIA	GASTROPODA SPP	ENVIRONMENT	STRATIGRAPHIC UNIT
	10 – 15						2	QU'APPELLE ALLUVIUM
	18			R	R		1	
	20							
	25				R			
	30				VC			
	35					R	3	QU'APPELLE CLAY
	40					R		
	45					R		
	50							
	55							
	60	VC		R				
	65	R						
	70	A		C	R		2	
	75	R		R				
	80	R						
	85°							
	90	R	R	R				
	95							
	100	R	R	C				
	105			R				
	110		R				1	
	115		R					
	120							
	125							
	130							

° NO SAMPLE

A ABUNDANT

VC VERY COMMON

C COMMON

R RARE

CLAY, CALCAREOUS

CLAY, NON-CALCAREOUS

SILTY CLAY

SILT

FIGURE 9.—DISTRIBUTION OF MOLLUSCS IN THE QU'APPELLE VALLEY SECTION

Pisidium cf. *superius* Sterki occurred in the Qu'Appelle Valley section and the Rocky Lake section in fair abundance (Figure 8). In the Rocky Lake section it occurred in the basal unit of the lower lacustrine unit along with *Gyraulus cyclostomus* Baker. *Pisidium* cf. *superius* Sterki did not appear in the upper lacustrine unit. In the Qu'Appelle Valley section *Pisidium* cf. *superius* was found to be present sporadically and not concentrated in any particular horizon (Figure 9).

Phylum ARTHROPODA

General Statement

Disintegration of lacustrine samples from the Regina Basin, Rouleau Basin, and Qu'Appelle Valley yielded seven genera and nineteen species of fresh water ostracods. The Moose Jaw and Regina Clays were barren of microfauna.

Preparation of material.- The ostracods with ornamentation were stained with methylene blue dye and sprayed with a light coating of ammonium chloride before photographing. Smooth shelled forms were placed on a depressed glass slide and immersed in an oil with a refractive index of 1.544 for photographing with transmitted light. This technique brought out muscle scars, pore canals, and the position of genital organs.

Ecology

General remarks.- Hoff (1942) pointed out that the type of bottom in which the ostracods were found had no bearing on the presence or absence of certain species. He did find that the velocity of the current was a factor in determining the environment of a species.

Redox potential and pH.- The redox potential present during the life cycle of the ostracod is indicated by the presence of authigenic minerals such as calcium sulphate. This, along with hydrogen ion concentration, to some degree, controls the presence of peat on which some ostracods feed. Also associated with peats are anerobic bacteria which are food for some ostracods. The lowest most fossiliferous sample in the Qu'Appelle Valley section carried *Cyclocypris forbesi* Sharpe, *Cypridopsis vidua* Muller, and *Eucandona* sp. A, *Eucandona poseyensis* (Staplin) and *Eucandona swaini* Staplin which all had an organic sepia brown pigmentation. *Cyclocypris forbesi* and *Cypridopsis vidua* are generally found in an environment with a low redox potential and an increased hydrogen ion concentration. The covering found on these two species is organic and is thought to protect the calcareous carapace from being dissolved in the slightly acidic environment. It has been noted by the author that this covering is not a biocharacter of the species but rather an environmental character; these two species have been studied from recent lakes in Saskatchewan, and have been found in many cases to have no covering. In one particular locality, the Sturgeon marl deposit, the two species are very common in an environment which has a pH well above 7.8.

Total dissolved solids.- In general, the genus *Limnocythere* occurred most abundantly in waters with a high total dissolved solids content. An investigation of two saline and one nonsaline lake in Saskatchewan revealed that there were greater populations of *Limnocythere* than *Eucandona* or any other fresh water genera in the saline lakes. This phenomenon was also noted in the Rouleau Basin where a period of evaporation caused the total dissolved content of the surface water to be very high. This is illustrated

graphically in Figure 7. Limnocythere sp. C and Limnocythere sp. G n. sp., which were the main representatives quantitatively of this genera, appear abundantly in the basal silty unit of the Rocky Lake Section. Limnocythere sp. G n. sp. is not known to be as abundant in the saline environment as Limnocythere sp. C n. sp. Benson (Moore, 1961, p. Q58) has interpreted increasing salinity as producing a more nodose population with respect to a smoothed-shelled population. This can be clearly seen with respect to the ostracod assemblages obtained from the highly saline Old Wives Lake and Lake Willowbunch, Saskatchewan.

Temperature.- Limnocythere sp. D, n. sp., was found in sediment that had been ice rafted. The basal part of the upper lacustrine unit of the Rocky Lake section was at one time in the near vicinity of the ice front where icebergs were prevalent. The ice rafted material from the icebergs was in the form of till-like sediment. The venter of the shell is built out to give the ventral region more stabilizing area against the currents. Further up the section, the ice rafted material disappears but the species continued to flourish. It should be noted that the following species were present in the same environment with Limnocythere sp. D, n. sp. after the icebergs melted: Eucandona swaini, Limnocythere sp. E, Limnocythere sp. C, n. sp. and Cytherissa lacustris.

The species Cypridopsis vidua and Cyclocypris forbesi are commonly found in stagnant ponds where the water is warm and shallow with abundant vegetation.

Regional Distribution

Few of the species studied from the clay and silt deposits associated with the lakes of the Regina Basin, Rouleau Basin, and Qu'Appelle

Valley have been found in Saskatchewan before. Eucandona caudata (Kaufmann) is a common species of Europe and the British Isles and was first reported in North America by Hoff (1942) from Illinois. Eucandona ohioensis (Furtos) was first reported in Ohio. Staplin (1953) reported it from several localities in Illinois.

Ilyocypris bradyi Sars and Ilyocypris gibba (Ramdohr) both have been described from northern Europe and North America. Both species have been found in Colorado, Illinois and Ohio. These species have been referred to as Holarctic by Hoff.

Cyprinotus pellucidus Sharpe has been found in Illinois, Idaho, Washington and Mexico. No Canadian previous occurrences have been recorded thus far. The author also obtained the species from Old Wives Lake and Lake Willowbunch in Saskatchewan.

Hoff reported Cypridopsis vidua (Muller) from lakes and ponds in Illinois as did Staplin (1953). The author has obtained this species from the Sturgeon marl deposit as well as from lakes in Saskatchewan. This species has been reported as being both Holarctic and Neotropical.

Cyclocypris forbesi Sharpe has been reported from Illinois and Massachusetts (Furtos, 1933).

Sars (1928) first recorded Cytherissa lacustris from Norway; Staplin (1953), described the same species from Illinois.

Of the limnocytherean species described by the author, a few are known to exist in lakes of Alberta (R. Green, personal communication).

There is great need for more detailed study of ostracod communities and populations in central and northern Canada. As can be seen from the foregoing discussion, the regional distribution of Pleistocene and Recent ostracods is very imperfectly known.

Ontogeny

The life history of the ostracod is reflected in the number of molt stages it undergoes. The ontogenetic study becomes very difficult as successive growth stages are shed and can not be followed or traced as growth lines on the shell surface. In this study the successive molts were assembled on the basis of size, shape and surface ornamentation. Dimorphism was exhibited by most species, generally, the female being smaller than the male. In many genera the dimensions of the left valve vary from those of the right valve.

Assuming that the proper instars have been measured, the application of Kesling's (1953) circular slide rule to dimensions of known adults of the species gives the number of instars and the dimensional limits of the instars. Graphically this can be represented by plotting length versus height on log log paper. It is noted that each instar progresses in size by a logarithmic factor of 26 per cent. On the basis of these graphs (Figures 12 to 25) the ontogenetic history of nine species is given.

As recorded by Swain (Moore, 1961, p. Q210) the fresh-water cypridaceans pass through nine molt stages, the latter being the adult. Of the five genera found in the superfamily Cypridacea, only one family represented by the genus Eucandona had nine molt stages (Figures 13 and 14). In the family Cyprididae the genus Cyprinotus was found to have eight molt stages while the genus Cypridopsis has only seven molt stages as has the genus Cyclocypris in the family Cyclocyprididae (Figure 12).

Two families in the superfamily Cytheracea have different numbers of instars. Kesling (Moore, 1961, p. Q19) indicates most cytheraceans have nine instars. In the family Cytherididae, the genus Cytherissa illustrates

LITHOLOGY	SAMPLE NUMBER	EUCANDONA SWAINI	LIMNOCYTHERE SP C
	1		
	2	R	
	3		
	4	R	
	5	R	R
	6	R	
	7	R	
	8	R	
	9	R	
	10	R	
	11	R	
	12		
XXXX	13		
XXXX	14		

SE COR S 4, T 14, R 23

LITHOLOGY	SAMPLE NUMBER	EUCANDONA SWAINI	ILYOCYPRIS BRADYI	ILYOCYPRIS GIBBA	CYTHERISSA LACUSTRIS	LIMNOCYTHERE SP C	LIMNOCYTHERE SP G
	1						
	2	R					
	3	A					
	4	A					A*
	5	A				R	R
	6	A				R	R
	7	A					R
	8	A					
	9	A					
	10	A					
	11	A					
	12	A					
	13	A	R	C	C	A	R
XXXX	14	A	R	R	A	C	
	15	C	R	R	C	VC	
	16	VC					

S.E. COR. S 14, T. 14, R 23

LITHOLOGY	SAMPLE NUMBER	EUCANDONA SWAINI	ILYOCYPRIS BRADYI	ILYOCYPRIS GIBBA	CYTHERISSA LACUSTRIS	LIMNOCYTHERE SP C	LIMNOCYTHERE SP G
	1						
	2	R					
	3	R					A
	4°						
	5	C					A
	6	R					
	7	R				R	
	8	R					
	9	R			R		R
	10°						
XXXX	11	A	R	VC	R	A	C
	12	C	R	R		R	R
	13	C		R		R	

S.E. COR. S. 24, T. 14, R. 23

LITHOLOGY	SAMPLE NUMBER	EUCANDONA SWAINI	ILYOCYPRIS GIBBA	CYTHERISSA LACUSTRIS	LIMNOCYTHERE SP C	CYCLOCYPRIS FORBESI
	1°					
	2°					
	3	R				
	4	VC				
	5	R				
	6	R			VC	
	7	C			C	
	8	A				
	9°					
	10	C	R	R		
	11	R	R	VC		
XXXX	12	R	C	R	R	R
	13					

N E COR. S 30, T. 14, R. 23

LITHOLOGY	SAMPLE NUMBER	EUCANDONA SWAINI	LIMNOCYTHERE SP C	GASTROPODA SPP	VERTEBRATA SPP
	1				
	2				
	3	VC	R		
	4	R			
	5	R			
	6		R		
	7°				
XXXX	8			R	
XXXX	9	R			
	10	R			R
XXXX	11			R	R
	12			R	
	13	R		R	

S E COR S 22, T 13, R 22

A ABUNDANT C COMMON

VC VERY COMMON R RARE

* Rare - <u>Limnocythere</u> sp. A

CLAY XXXX GYPSUM

° NO SAMPLE FOR THIS DEPTH (FEET)

FIGURE 10 — DISTRIBUTION OF OSTRACODS IN THE ROULEAU BASIN

Lithology	Sample Number (Depth in Feet)	*Cypridopsis vidua*	*Cyclocypris forbesi*	*Eucandona fossulensis*	*Eucandona ohioensis*	*Eucandona poseyensis*	*Eucandona swaini*	*Eucandona sp A*	*Ilyocypris bradyi*	*Ilyocypris gibba*	*Limnocythere sp B*	*Limnocythere sp C*	*Limnocythere sp G*	Environment	Stratigraphic Unit
Silt	10 — 15						R		R		R	C	C	2	Qu'Appelle Alluvium
Clay, non-calcareous	18													1	Qu'Appelle Alluvium
Silty clay	20	C	R				VC		R		A	R	A	1	Qu'Appelle Alluvium
Silty clay	25						C							1	Qu'Appelle Alluvium
Silty clay	30													1	Qu'Appelle Alluvium
Clay, non-calcareous	35						R							3	Qu'Appelle Clay
Clay, non-calcareous	40						VC							3	Qu'Appelle Clay
Clay, non-calcareous	45						R							3	Qu'Appelle Clay
Clay, non-calcareous	50						R							3	Qu'Appelle Clay
Clay, calcareous	55						A		R			VC		3	Qu'Appelle Clay
Clay, calcareous	60						A							3	Qu'Appelle Clay
Clay, calcareous	65						A							3	Qu'Appelle Clay
Clay, calcareous	70						A							2	Qu'Appelle Clay
Clay, calcareous	75						A						R	2	Qu'Appelle Clay
Clay, calcareous	80						A							2	Qu'Appelle Clay
Clay, calcareous	85°													2	Qu'Appelle Clay
Clay, calcareous	90						A							2	Qu'Appelle Clay
Clay, calcareous	95						A			R				2	Qu'Appelle Clay
Clay, calcareous	100		R				A							2	Qu'Appelle Clay
Clay, calcareous	105*		R		R		A							2	Qu'Appelle Clay
Clay, calcareous	110**	R					A			VC		VC		1	Qu'Appelle Clay
Clay, calcareous	115				R		C							1	Qu'Appelle Clay
Clay, calcareous	120		A	R		R	A	R		R				1	Qu'Appelle Clay
Clay, calcareous	125		R				C		R					1	Qu'Appelle Clay
Clay, calcareous	130		R	R			C			R		R	R	1	Qu'Appelle Clay

* Rare - Cyprinotus pellucidus
** Rare - Limnocythere sp. A

° NO SAMPLE

A ABUNDANT

VC VERY COMMON

C COMMON

R RARE

CLAY, CALCAREOUS

CLAY, NON-CALCAREOUS

SILTY CLAY

SILT

FIGURE 11 —DISTRIBUTION OF OSTRACODS IN THE QU'APPELLE VALLEY SECTION

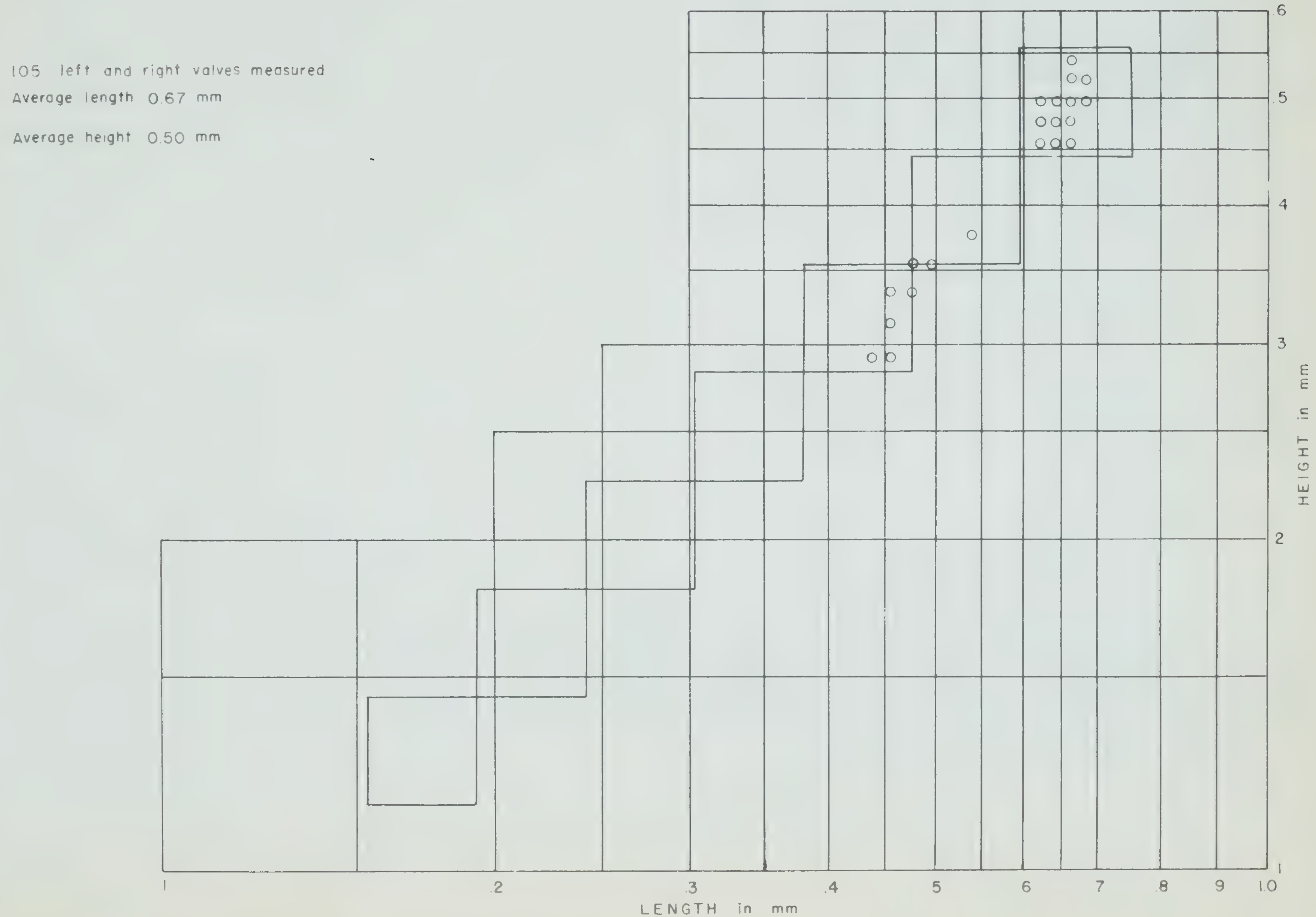

FIGURE 12 — ONTOGENY OF *CYCLOCYPRIS FORBESI*

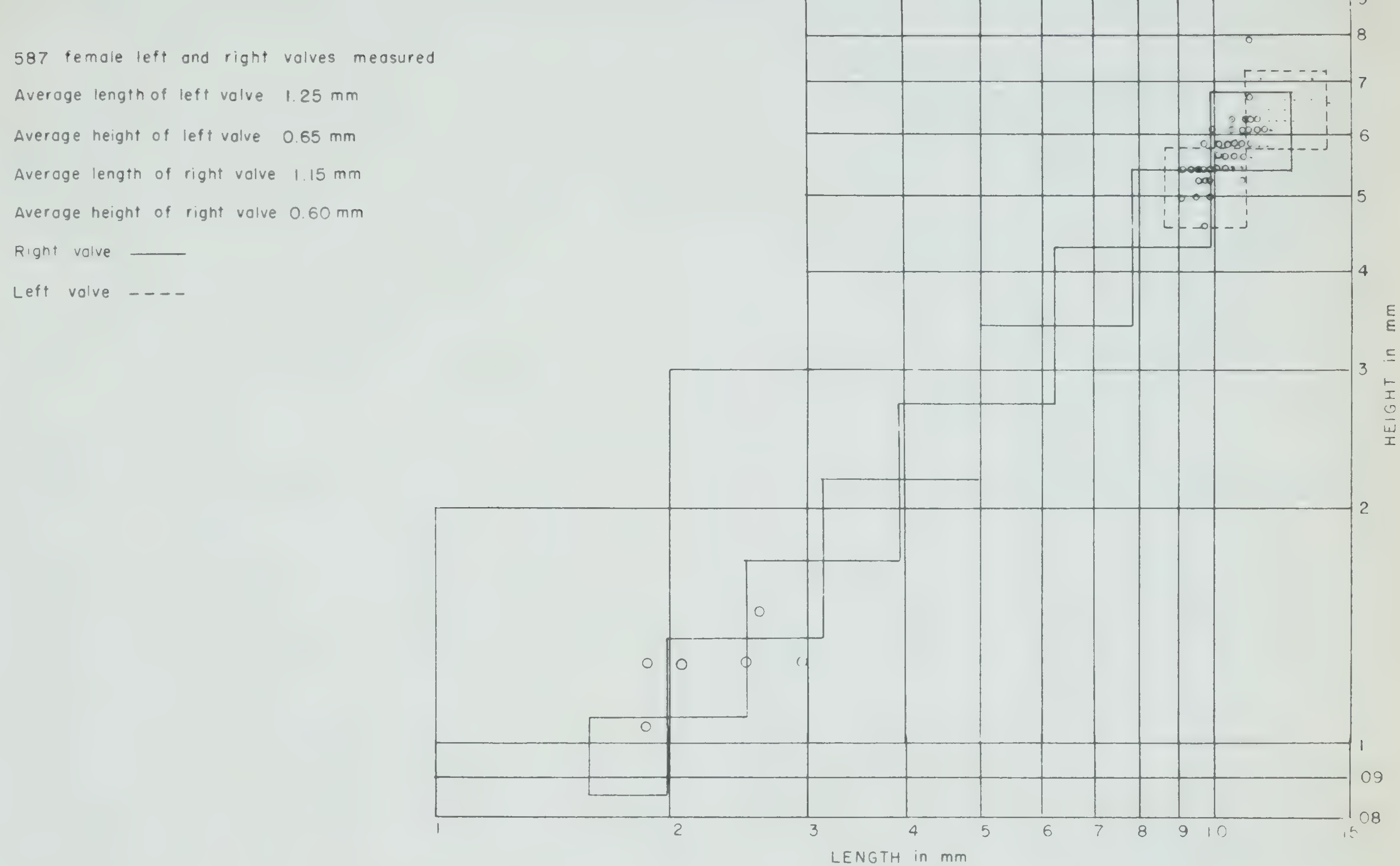

FIGURE 13. — ONTOGENY OF *EUCANDONA SWAINI* (female)

175 male left and right valves measured

Average length 1.25 mm

Average height 0.70 mm

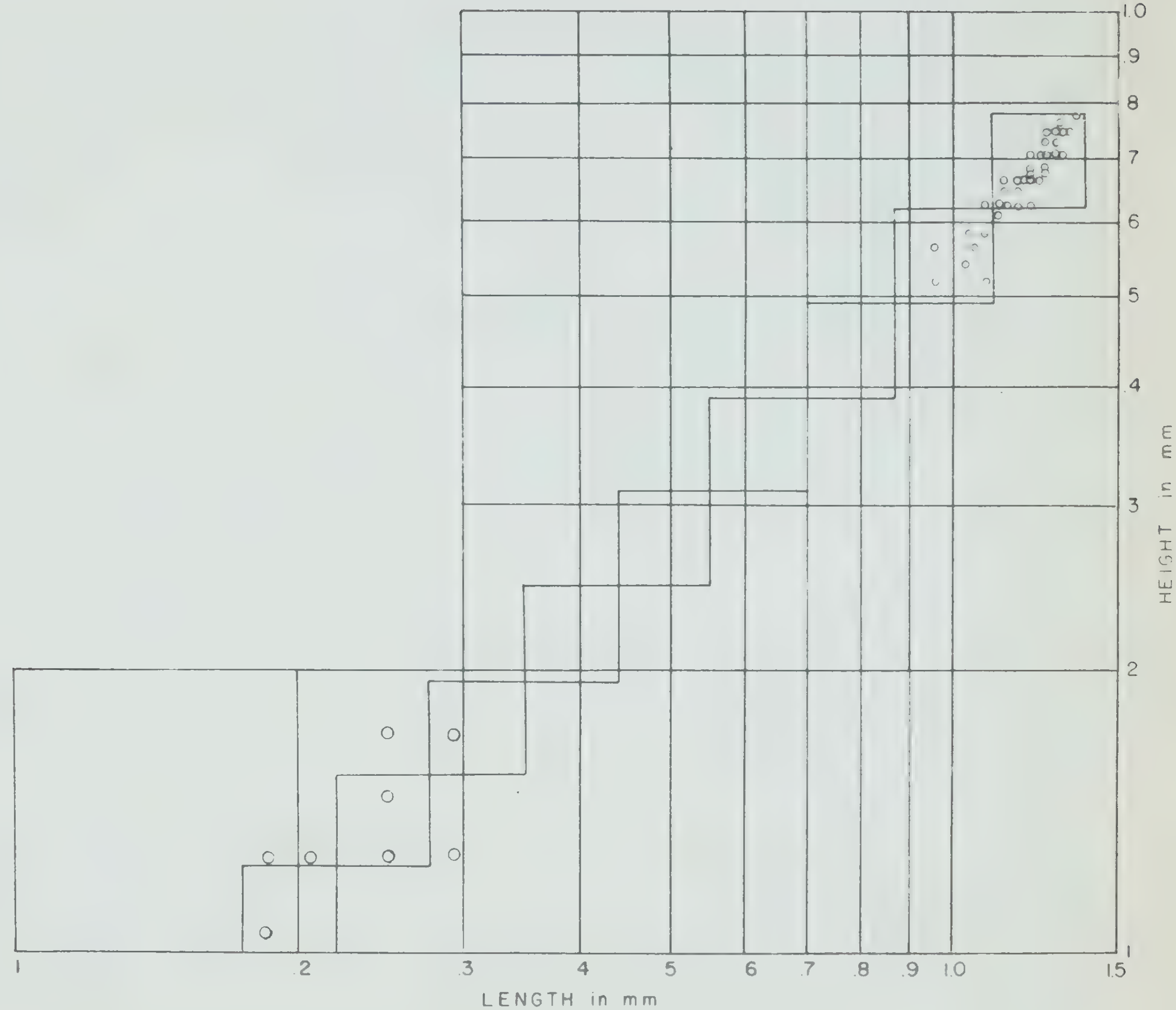

FIGURE 14 — ONTOGENY OF *EUCANDONA SWAINI* (male)

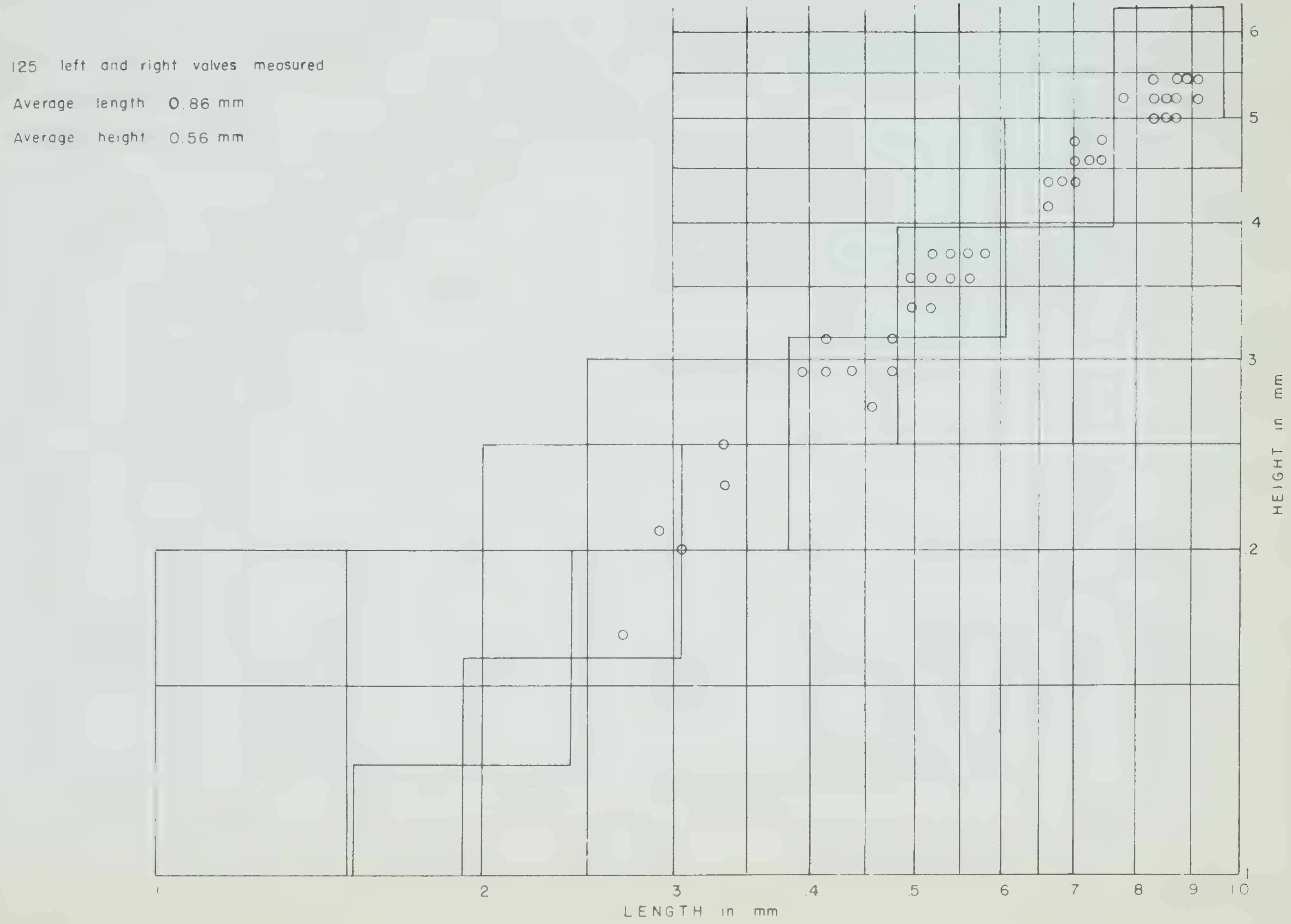

FIGURE 15 —ONTOGENY OF *CYTHERISSA LACUSTRIS*

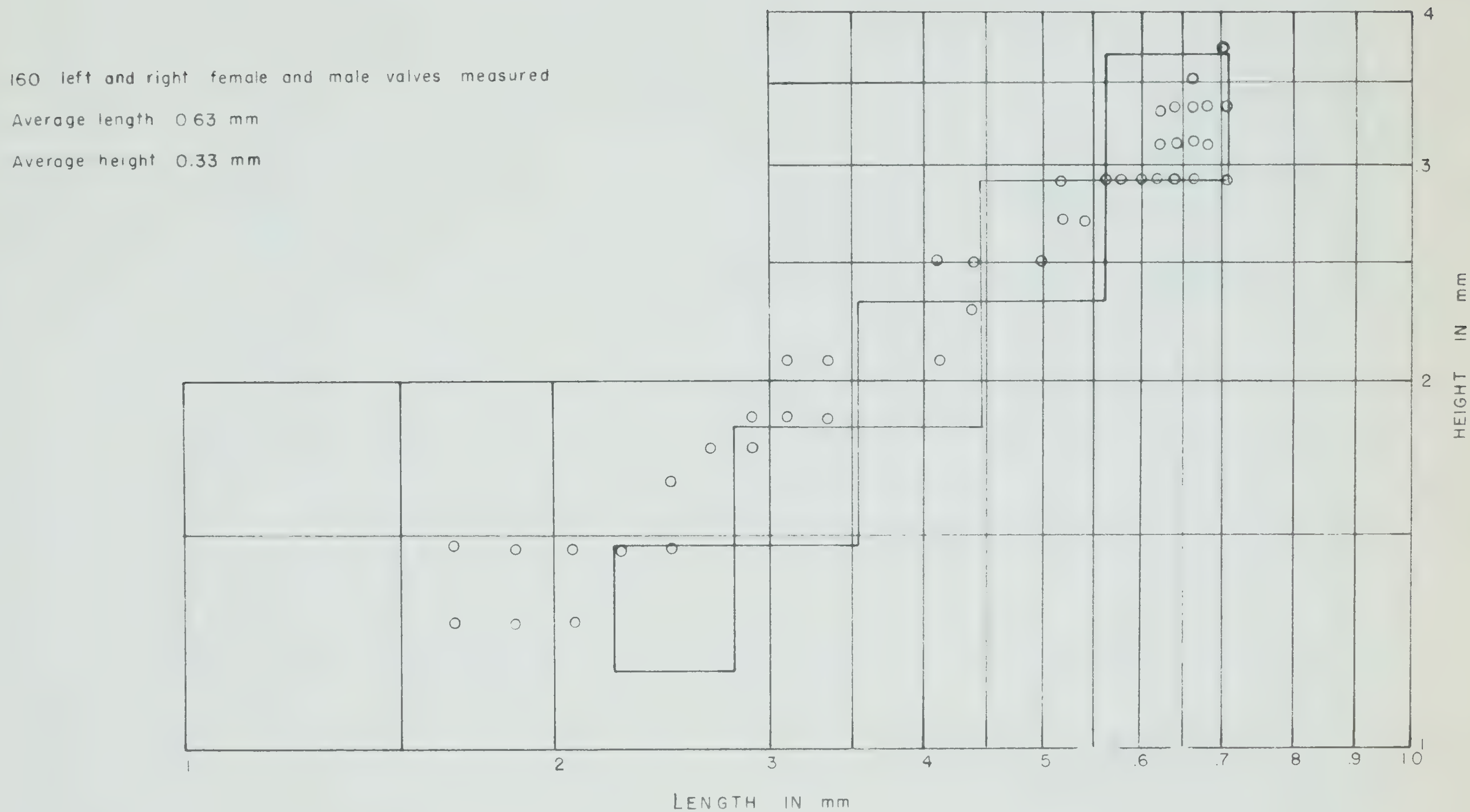

FIGURE 16 — ONTOGENY OF *LIMNOCYTHERE SP A*

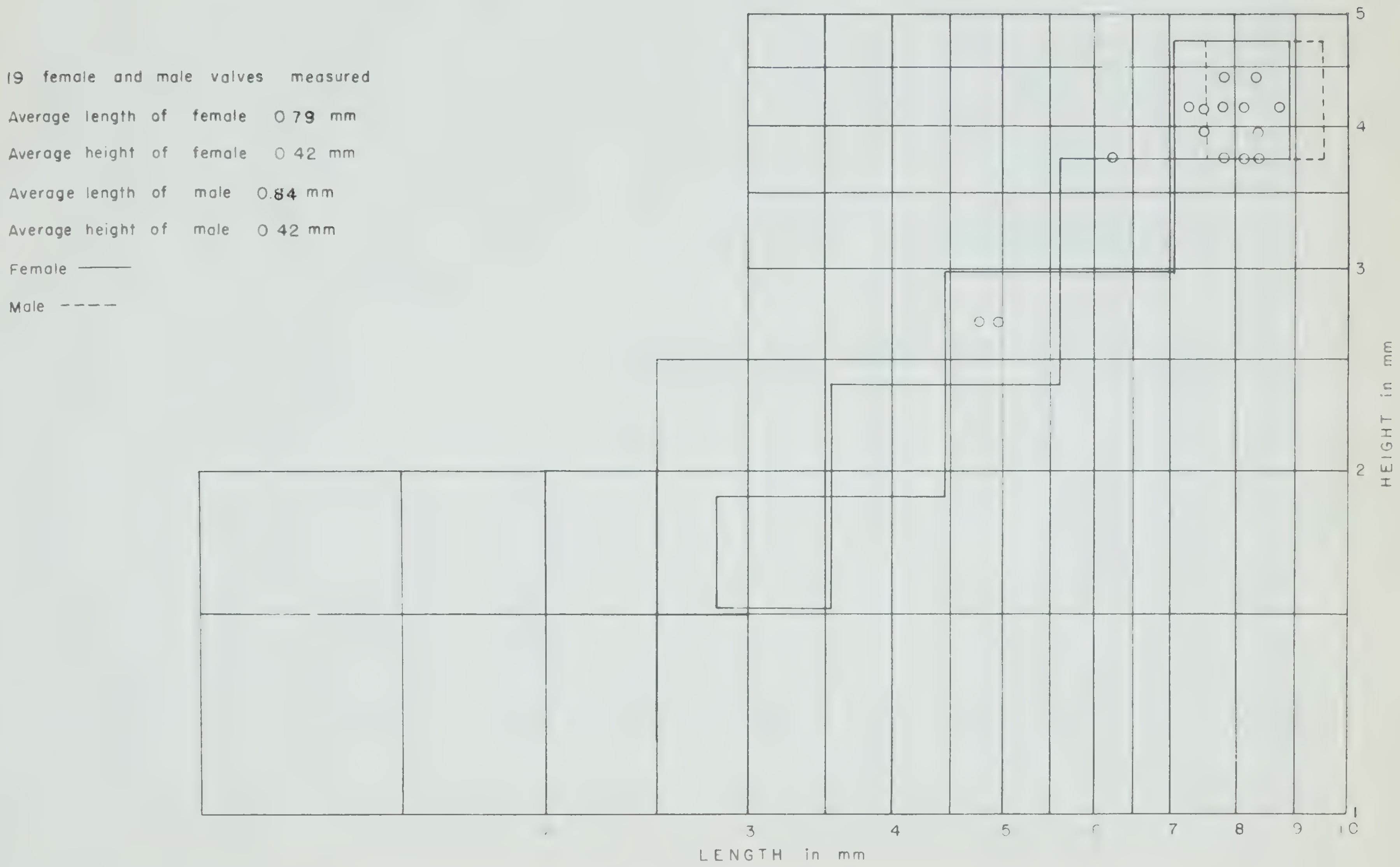

FIGURE 17 —ONTOGENY OF *LIMNOCYTHERE SP B*

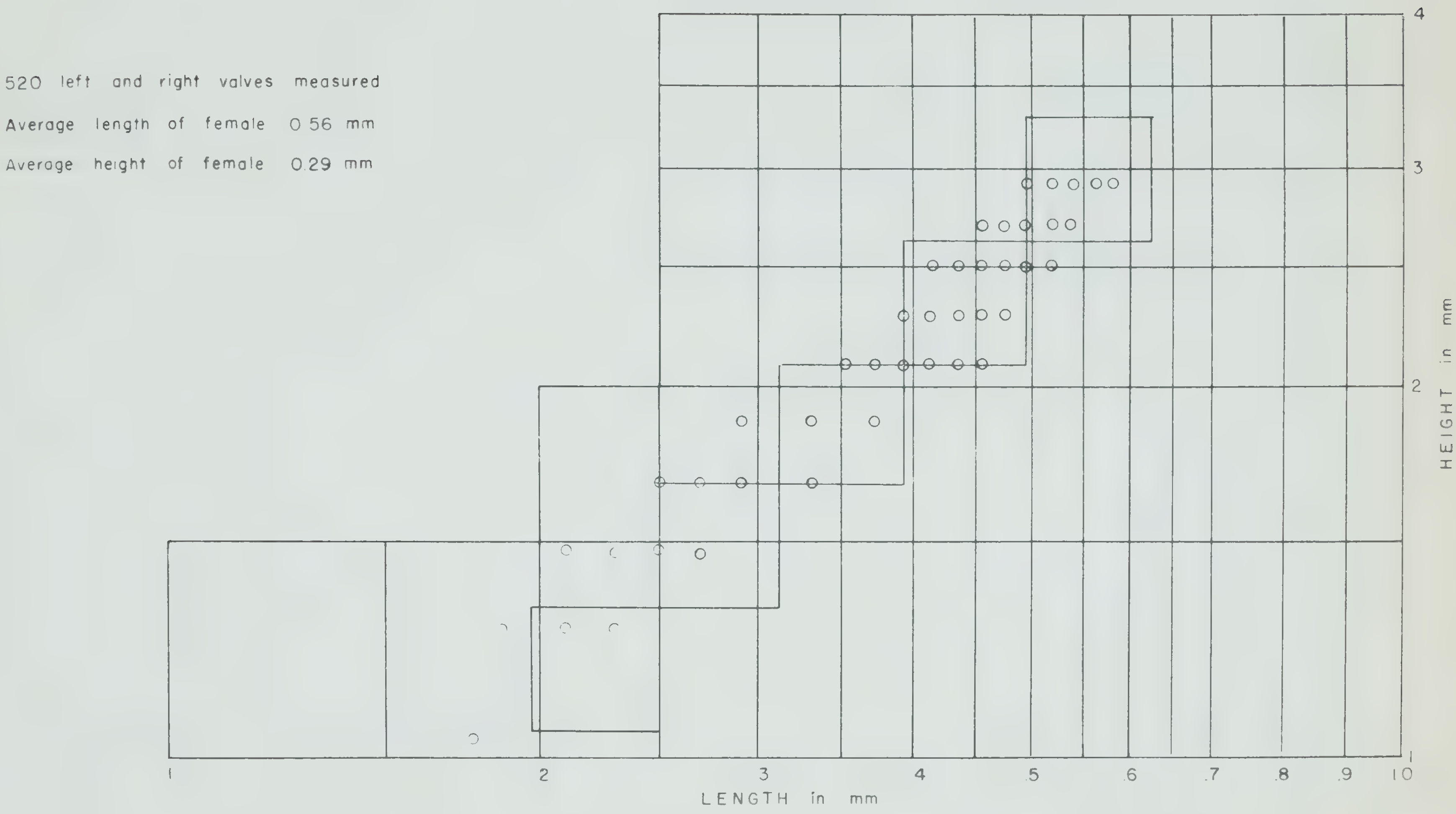

FIGURE 18.—ONTOGENY OF *LIMNOCYTHERE SP C* (female)

590 left and right valves measured

Average length of male 0.56 mm

Average height of male 0.30 mm

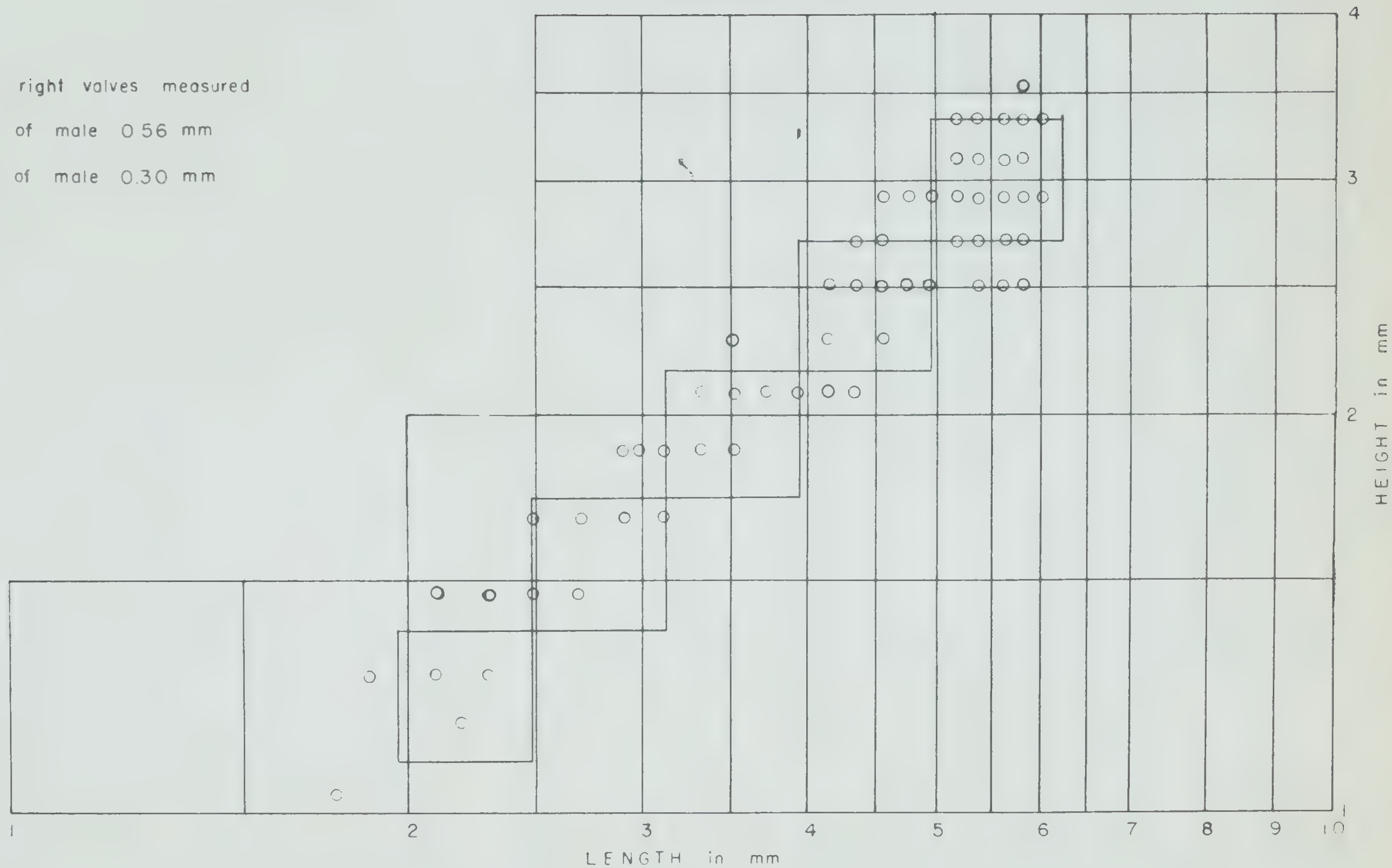

FIGURE 19 —ONTOGENY OF *LIMNOCYTHERE SP C* (male)

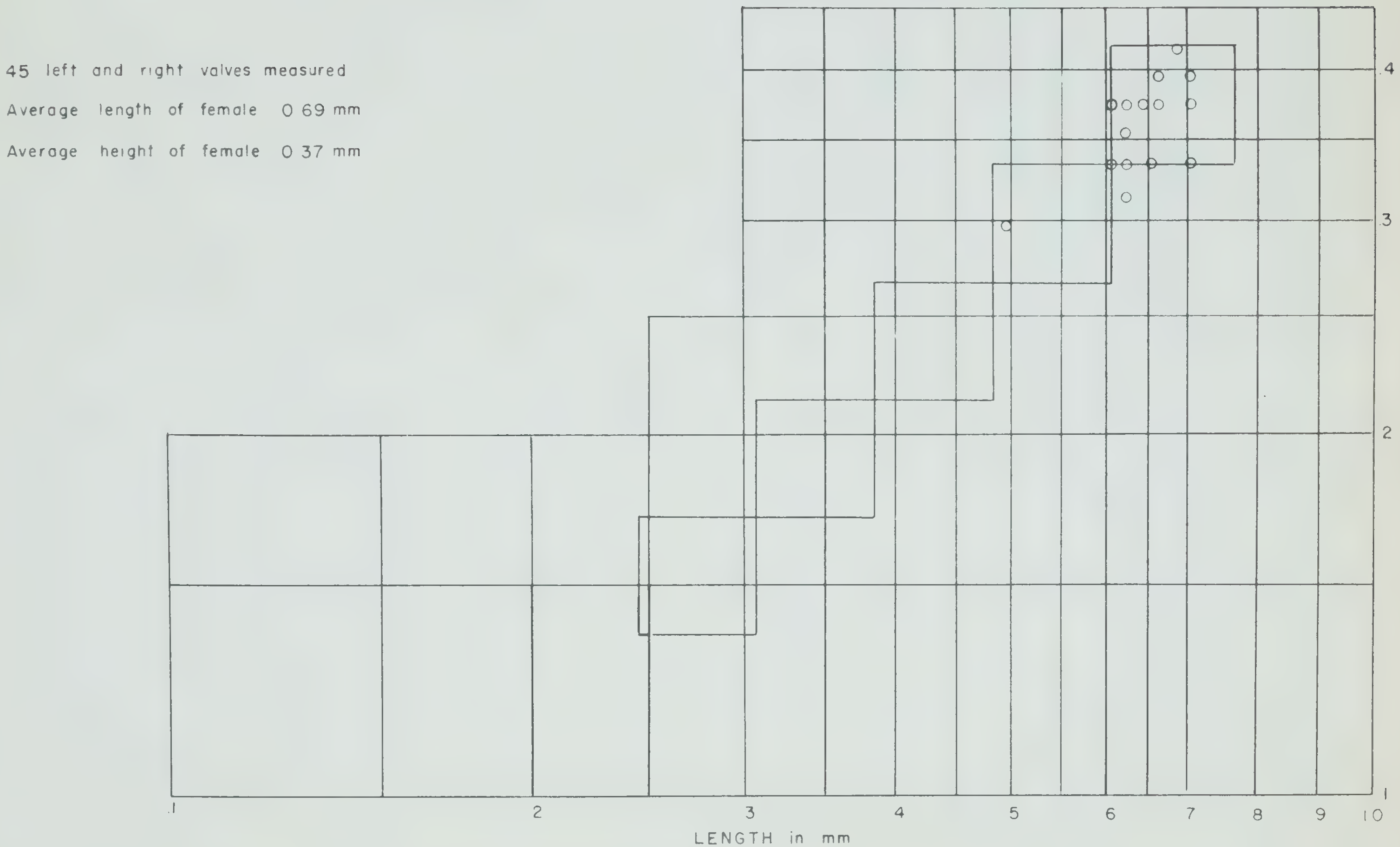

FIGURE 20 — ONTOGENY OF *LIMNOCYTHERE* SP D (female)

FIGURE 21. —ONTOGENY OF *LIMNOCYTHERE SP D* (male)

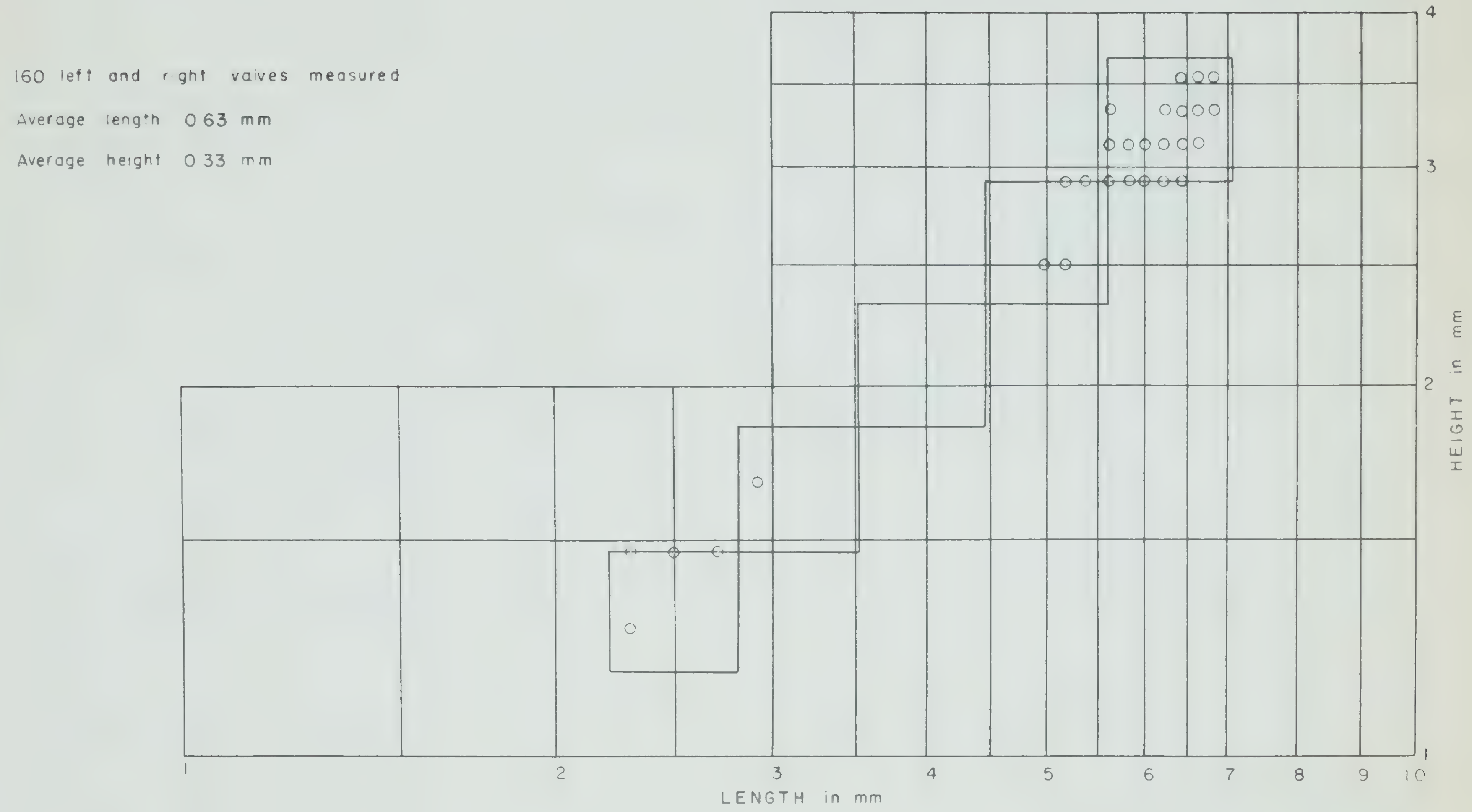

FIGURE 22 .—ONTOGENY OF *LIMNOCYTHERE* SP F

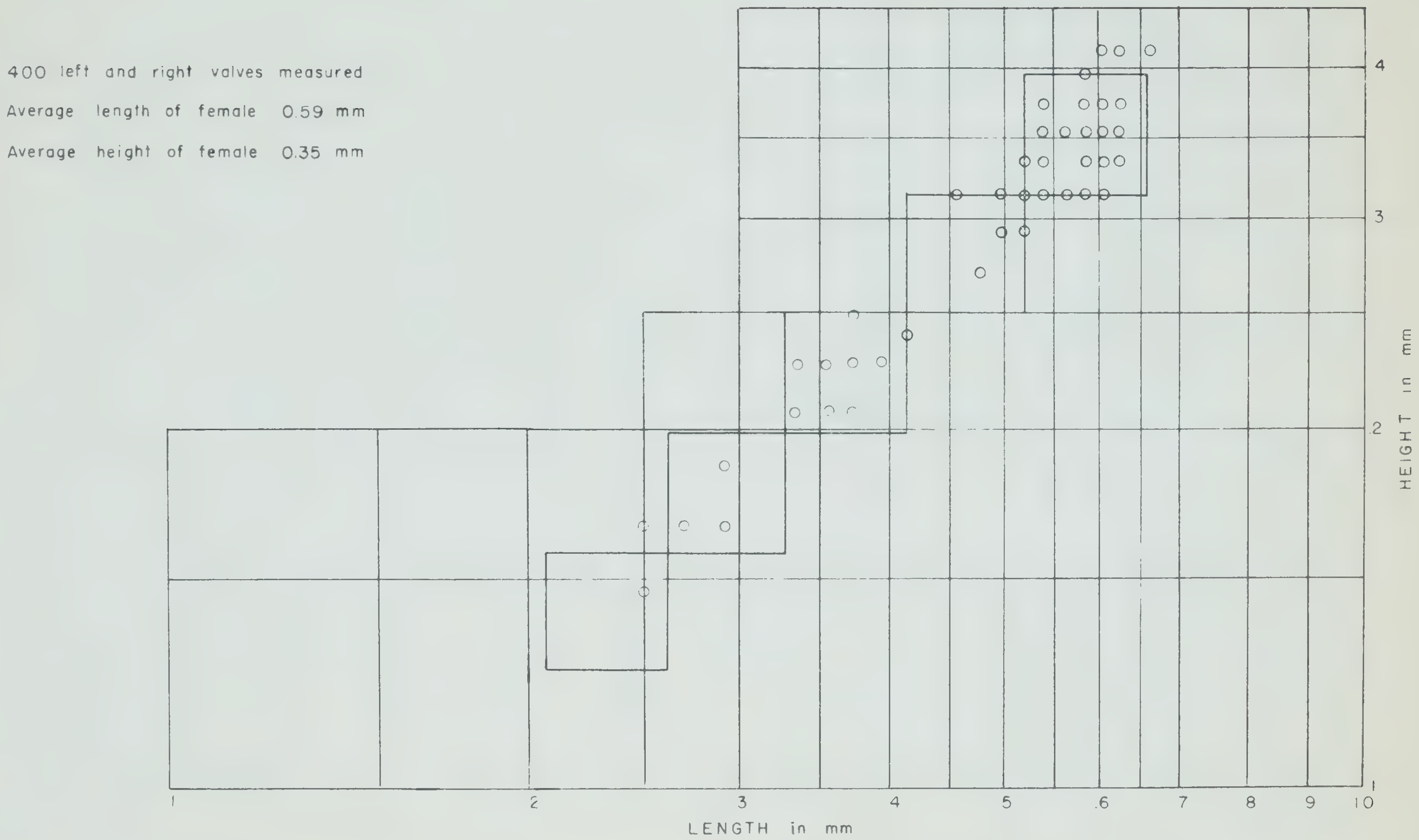

FIGURE 23 .—ONTOGENY OF *LIMNOCYTHERE SP G* (female)

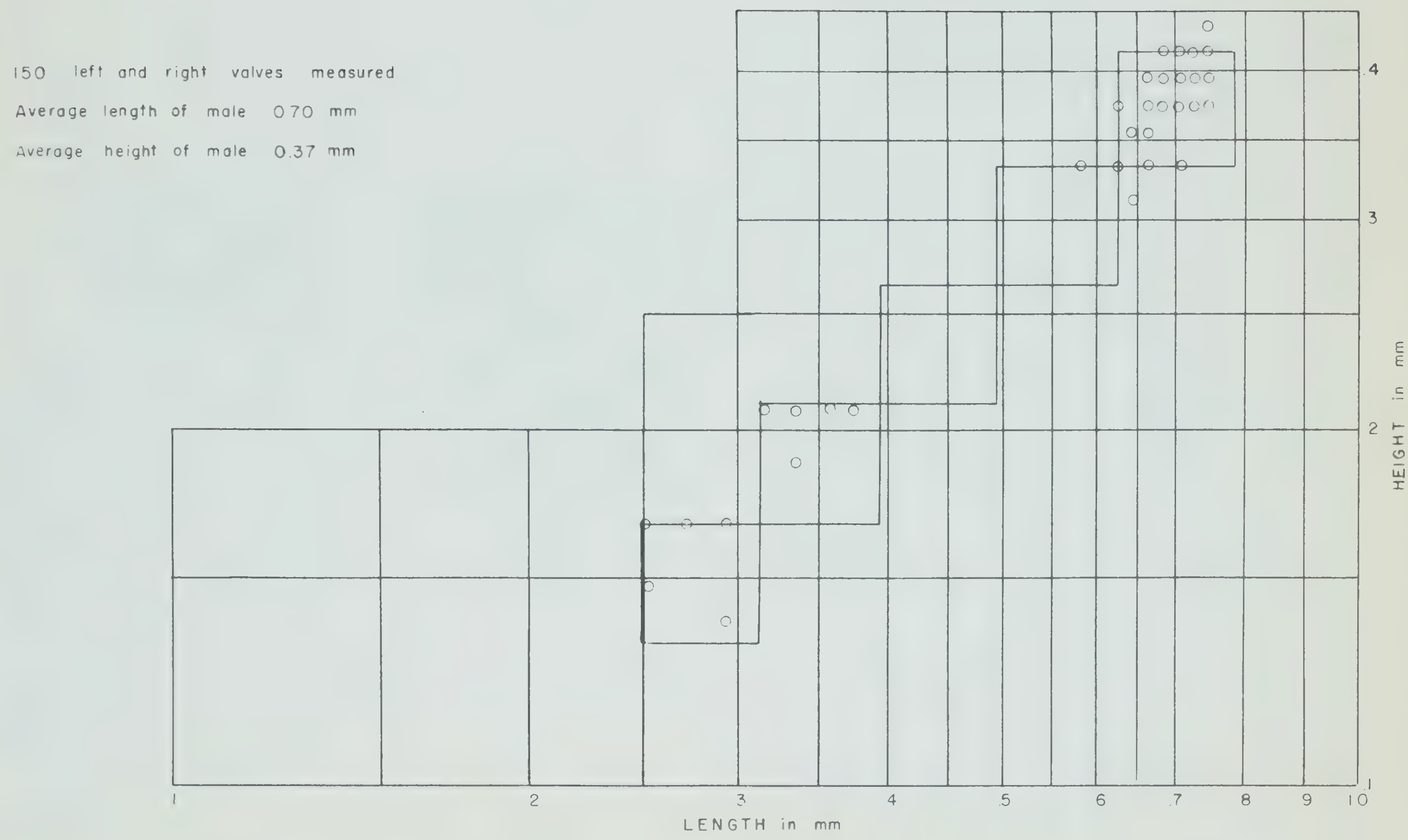

FIGURE 24 —ONTOGENY OF *LIMNOCYTHERE SP G* (male)

eight molt stages (Figure 15) while the genus Limnocythere from the family Limnocytheridae has five molt stages (Figures 16 to 25).

Reproduction

The recognition of dimorphism in certain species and its absence in others has led many authors to acknowledge both syngamic and parthenogenic reproduction. Hoff (1942, p. 36) gave a list of those fresh-water ostracods in which he has noted parthenogenic-syngamic reproduction. The present author's list agrees with that of Hoff except for the species Cyclocypris forbesi Sharp as only females were found in this study. It is noted that Furtos (1933) described the male of this species but Hoff (1942) did not observe it in his collection.

Males not recorded:

Cyclocypris forbesi Sharpe
Cypridopsis vidua (Muller)
Cyprinotus pellucidus Sharpe
Cytherissa lacustris Sars
Eucandona poseyensis (Staplin)
Eucandona fossulensis (Hoff)
Eucandona caudata (Kaufmann)
Ilyocypris bradyi Sars
Ilyocypris gibba (Ramdohr)
Limnocythere sp. E
Limnocythere sp. F, n. sp.

Males and females recorded:

Eucandona swaini Staplin, n. sp.
Eucandona ohioensis (Furtos)
Eucandona sp. A
Limnocythere sp. A, n. sp.
Limnocythere sp. B, n. sp.
Limnocythere sp. C, n. sp.
Limnocythere sp. D, n. sp.
Limnocythere sp. G, n. sp.

The total populations of Eucandona poseyensis, E. fossulensis and Limnocythere sp. E are not large enough to positively ascertain whether or not the males are absent.

Taxonomy

Two species were not named as new species because of their rarity. In the event that more material becomes available these forms will be referred to a described species or given a new specific name.

The classification adopted here is that presented by Benson *et al*. (Moore, 1961, p. Q99). This classification is used because it has been developed by sixteen authors who have studied ostracods in North America, Europe and Asia. The scheme makes use of certain soft parts where possible.

The ostracods described fall into two superfamilies, Cypridacea and Cytheracea. Four families are represented in the superfamily Cypridacea, each family being represented by one genus except the family Cyprididae which has two genera. The superfamily Cytheracea has two families each represented by one genus. The family Eucandonidae has one genus with seven species. The family Limnocytheridae also has one genus with seven species. All other families have one genus and species except for the family Ilyocyprididae in which two species were found belonging to the genus *Ilyocypris*.

PALAEOECOLOGY

Glacial Lake Moose Jaw

The palaeoecology of Lake Moose Jaw was one of oxidation and moderate water temperatures. The lack of preservation of any amount of vegetable matter combined with the presence of limonite in the clay indicates that the lake was well aerated giving the water a redox potential above zero. The temperature of the water varied with the season, however, it is thought that with the close proximity of the glacier, the water

temperature remained low. Ostracods, gastropods, and pelecypoda are not known to have inhabited the environment, possibly because of the lack of food.

Glacial Lake Regina

The palaeoecology of Glacial Lake Regina did not vary greatly from the conditions during the existence of Lake Moose Jaw. Vegetable matter is not preserved in the lacustrine clay indicating that the redox potential was above zero. The presence of limonite further substantiates this. Water derived mainly from the glacier and proglacial areas tended to keep the lake temperatures low. Ostracods, gastropods, and pelecyopods are not known to have inhabited the environment, possibly because of the lack of food.

Glacial Lake Condie

The palaeoecology of Glacial Lake Condie was similar to the previous two lakes in the Regina Basin. The temperature of the water was low with the constant influx of meltwater from the retreating glacier.

Lake Rouleau

The presence of oxidized clay at the base of the Rouleau Clay indicates that the Rouleau Basin was formed before Glacial Lake Condie was completely drained. During this period ostracods and gastropods began inhabiting the environment, indicating a change in the physical-chemical environment from that of Lake Condie. Further oxidation of the already oxidized Regina and Condie Clays did not occur because the redox potential was low enough to reduce the ferric iron to ferrous iron. With a pH of 7.8 or higher, calcium carbonate precipitated and formed the shells of

organisms. During this period, the Rouleau Lake became dry by total evaporation. This is shown (Figure 7) by the presence of a high sulphate-carbonate zone forming an incipient evaporite deposit. At this time, the lake contained the richest ostracod population qualitatively (Figure 10). The abundance of ornamented ostracods such as *Limnocythere* and *Ilyocypris* tends to indicate a permanent lake with a relatively high total dissolved solid content. *Ilyocypris* is generally found in running water, but is known to live in ponds and lakes with muddy bottoms. It is possible that *Ilyocypris bradyi* and *I. gibba* were brought in by small streams emptying into the Rouleau Basin.

With a redox potential of -0.1 to -0.3 (Mason, 1958, p. 162) the incoming clays were reduced. In this environment, algae and charophytes thrived, providing abundant food for ostracods and gastropods. In the type section the change in colour from brown to grey clay, 12 feet below the surface, marks the pronounced depositional environmental change. The summer temperature during this period is thought to have been in the 20-25° C range. Water was received into the basin as rain and snow, therefore, there were seasonal variations in the temperature.

During the last stages of Rouleau Lake, sedimentation had reduced the volume of water that the basin could hold. Excess water overtopped the old channel outlet and drained down Moose Jaw Creek. During this period, ferns? quickly invaded the lake surface. This is evidenced by the abundance of fern? sporangia in the top 2 feet of Rouleau Clay. The only ostracod which was capable of surviving in this environment was *Eucandona swaini*. This species tells little about the environment, however, because it is found in many different types of aqueous habitats.

Qu'Appelle Lakes

The environments discussed below are valid only for that region near the reference section and do not necessarily apply to other parts of the Qu'Appelle Valley. The Qu'Appelle Valley Clay was deposited in three environments (Figure 11). The first environment is encountered from 130 to 110 feet from the surface, a thickness of 20 feet. The initial environment was one of shallow, warm water with abundant vegetation. The presence of the ostracods Cyclocypris forbesi and Cypridopsis vidua indicates a pH of possibly less than 7.8. Later the pH increased to 7.8 or higher. The end of this period was marked by the drying up of the body of water. The presence of fern? sporangia indicates extremely shallow water with an increase in total dissolved solids. This environment is similar to the one which existed during the final stages of Rouleau Lake.

The second environment is again marked initially by shallow warm water, however, the depth of water increased rapidly. The pH of the initial stages approached 7.8 but increased quickly to more than 7.8. During this second phase pelecypods and gastropods began to invade the environment and reached their acme with a Valvata tricarinata zone, 75 feet below the surface or 5 feet below the top of the second phase. The molluscan fauna then decreased rapidly. The presence of Valvata tricarinata indicates a lake 10 to 20 feet deep, with a muddy bottom and restricted current activity. This second phase also ended with the lake drying up almost completely. Fern? sporangia, as before, indicate extremely shallow water with an increase in total dissolved solids.

The third and last environmental change in the Qu'Appelle Clay occurs from 30 to 70 feet from the surface, and is marked by two

environments--calcareous and non-calcareous. The lower 20 feet of sediments are calcareous, indicating a pH of at least 7.8 or higher. This zone contains ostracods and Valvata tricarinata (Say), the latter having continued on from the previous environmental phase. The upper 20 feet consist of non-calcareous to slightly calcareous sediments. Eucandona swaini which has persisted throughout the section continued to do so even in this environment. It is thought that the pH was less than 7.8 and that this inhibited carbonate deposition. In the latter stages of the lake, the volume of water was reduced greatly. Fern? sporangia abounded on this surface.

The Qu'Appelle Alluvium was deposited in two environments. Conceivably, these environments were in some way related to the meandering Qu'Appelle River. The environments were established slowly as illustrated by the scarcity of fauna and flora. Eucandona swaini was re-established in the environment while the fern? sporangia from the previous environment continued to thrive. Towards the end of the fine sand deposition, the water became much more favourable for habitation by organisms. Cyclocypris forbesi indicates a relatively shallow and warm water environment. The other ostracod species support this interpretation as they developed an organic pigmentation. The water contained abundant vegetation rooted in the sediment that were then being deposited. During this latter phase ferns? again became established.

The top 15 feet of the Qu'Appelle Alluvium was deposited during the second environmental phase. As the body of water became more active Cyclocypris forbesi and the fern? sporangia disappeared. Ilyocypris bradyi and some limnocythereans along with the silty composition of the bottom indicates some current activity.

Rocky Lake Section

Only the palaeoecology of the lower and upper lacustrine units will be discussed (Figure 8). The abundance of Eucandona swaini, Limnocythere sp. C, and L. sp. F, L. sp. G with Gyraulus cyclostomus indicates an environment with water in motion, possibly that of a small stream with a silty bottom. It is possible that the redox potential was positive and caused limonite to precipitate. Since the water in the stream probably came from the ice across till, it could have been heavily charged with carbonates. In any case, the pH was above 7.8 and allowed for the formation of calcareous shells. Food for the organisms was obtained directly from phyto-plankton; though plants may have existed along the edges of the stream course, there is no carbonaceous matter preserved. Higher in the lower lacustrine unit, it appears as though the environment changed somewhat because the quantitative population subsided rapidly. The main factor which affected the habitat was the loss of stream power or competency. The bottom became muddy and the reduction in currents caused those organisms previously mentioned to seek ecological niches elsewhere. Mud burrowers and bottom creepers like Eucandona continued to live in the changing environment. An apparent reactivation of the ice front caused sands and gravels to cover the lower lacustrine unit, thereby, ending an environment suitable to habitation by organisms such as ostracods and molluscs.

The temperature during the beginning of the upper lacustrine unit or Condie Clay was extremely low. The species Limnocythere sp. D, which was in till-like material, has a broad venter so that it might stablize itself against the currents when it crept along the bottom of the lake. From ice-rafted sediment it is known that icebergs occupied the waters

for some time, keeping the temperature low. Limnocythere sp. D was the only ostracod present when the water was extremely cold. Once the icebergs melted and the water warmed up, other ostracods appeared. Cytherissa lacustris, which has been reported from Norway in a cold deep water environment, inhabited this portion of the lake along with Eucandona swaini. The environment found in this section of the Condie Clay was local and may not represent the overall condition of Glacial Lake Condie.

SYSTEMATIC DESCRIPTIONS

Phylum ARTHROPODA

Subphylum MANDIBULATA

Subclass OSTRACODA Latreille, 1806

Order PODOCOPIDA Muller, 1896

Suborder PODOCOPINA Sars, 1866

Superfamily CYPRIDACEA Baird, 1845

Family CYPRIDIDAE Baird, 1845

Subfamily CYPRIDINAE Baird, 1845

Genus CYPRINOTUS Brady, 1886

CYPRINOTUS PELLUCIDUS Sharpe, 1897

Plate 4, figure 1

Cyprinotus pellucida Sharpe, 1897, Illinois Lab. Nat. Hist. Bull., v. 4, p. 434-435, pl. 42, figs. 1-6.

Cyprinotus pellucidus Sharpe. Hoff, 1942, Illinois Biol. Mon., v. 19, no. 1-2, p. 146 (synonymy).

Shell subelliptical in side view, acutely pointing in anterior region in dorsal view. Dorsal margin evenly arched; ventral margin concave; anterior and posterior margins evenly rounded. Shell surface smooth, transparent to translucent.

Hingement primitive. Adductor muscle scar composed of seven subparallel elongate loosely knitted depressions orientated diagonally across shell; mandibular scar anteroventral of adductor scar; antennal scar anterodorsal from adductor muscle scar.

Duplicature weakly formed; line of concrescence well defined; anterior vestibule well developed with inner margin semi-circular in

outline. Tubercles fringe edge of anterior margin; area of shell surface above vestibule pitted.

Measurements of hypotype.--

	Length	Height	Valve
female:	0.92 mm.	0.54 mm.	right G.M.U.S.-Ao-1 (fig. 1)

Locality and level of hypotype.--Qu'Appelle Valley section (Figure 11), from clay unit 105 feet below the surface.

Distribution.-- The figured specimen marks the only occurrence of this species in the study area. The author has also obtained this species from Old Wives Lake and Willowbunch Lake, Saskatchewan.

Hypotype.-- Geological Museum, University of Saskatchewan.

Subfamily CYPRIDOPSINAE Kaufmann, 1900

Genus CYPRIDOPSIS Brady, 1867

CYPRIDOPSIS VIDUA (Muller), 1776

Plate 4, figures 2-4

Cypris vidua Muller, 1776, Zool. Danicae Prodromus, Havniae, p. 199.

Cypridopsis vidua (Muller). Hoff, 1942, Illinois Biol. Mon., v. 19, no. 1-2, p. 151-153, pl. 8, figs. 115-117 (synonymy).

Shell subtriangular in side view, acutely pointing in anterior region in dorsal view. Doraal margin convex, highly arched; ventral margin nearly straight, slightly concave; anterior and posterior margins broadly rounded. Shell surface bears small pits at exterior ends of normal pore canals; carapace generally sepia brown, rarely white, translucent.

Left valve larger than right valve with prominent overlap on ventral margin; dentition consists of shallow recess below dorsal margin

of left valve for receipt of right valve. Adductor muscle scar forms cluster of four oval depressions, one central scar with three anterior scars; one mandibular scar anteroventral from cluster; two suboval antennal scars anterodorsal from adductor scar.

Duplicature weakly developed, forms flap in center of right valve; line of concrescence poorly defined; anterior vestibule well developed with inner margin subrounded in outline; posterior vestibule poorly developed.

Measurements of hypotypes.--

	Length	Height	Valve
female:	0.75 mm.	0.46 mm.	right G.M.U.S.—Ao-2 (fig. 2)
	0.67 mm.	0.42 mm.	left G.M.U.S.—Ao-3 (fig. 3)
female carapace	0.75 mm.	0.50 mm.	right G.M.U.S.—Ao-4 (fig. 4)
	0.78 mm.	0.52 mm.	left

Locality and level of hypotypes.-- Qu'Appelle Valley section (Figure 11), from clay unit 120 feet below the surface.

Distribution.-- The species occurs in the Qu'Appelle Valley section at levels of 110, 105 and 20 feet below the surface. It also occurs in the Rocky Lake Section, 2 feet below the top of the lower lacustrine unit. The author has found the species in Waskana Lake and the Sturgeon Lake marl deposit of Saskatchewan.

Hypotypes.-- Geological Museum, University of Saskatchewan.

Family CYCLOCYPRIDIDAE Kaufmann, 1900

Genus CYCLOCYPRIS Brady & Norman, 1889

CYCLOCYPRIS FORBESI Sharpe, 1897

Plate 4, figures 5-7

Cyclocypris forbesi Sharpe, 1897, Illinois Lab. Nat. Hist. Bull., no. 4, p. 432-433, pl. 41, figs. 1-7.

Cyclocypris forbesi Sharpe. Hoff, 1942, Illinois Biol. Mon., v. 19, no. 1-2, p. 102-103, pl. 6, figs. 73-75 (synonymy).

Shell subovate in side view, acutely pointing in anterior region in dorsal view, greatest height posterior of center. Dorsal margin convex, highly arched; ventral margin nearly straight, slightly convex; anterior and posterior margins broadly rounded. Minute normal pore canals interrupt smooth shell surface; color of carapace sepia brown, rarely white, transparent to translucent.

Right valve larger than left valve; dorsal edge of left valve vaulted against edge of right valve, overlap accentuated in mid-ventral region by flap produced by duplicature. Adductor muscle scar forms cluster of five oval depressions consisting of two central scars with three anterior scars; two mandibular scars anteroventral from cluster; one suboval antennal scar anterodorsal from adductor scar.

Duplicature very weakly developed; line of concrescence poorly defined; anterior vestibule incipiently developed, forms recess in left valve.

Measurements of hypotypes.--

	Length	Height	Valve
female:	0.66 mm.	0.50 mm.	right G.M.U.S.-Ao-5 (fig. 5)
	0.66 mm.	0.48 mm.	left G.M.U.S.-Ao-6 (fig. 6)
female carapace	0.67 mm.	0.52 mm.	right G.M.U.S.-Ao-7 (fig. 7)
	0.66 mm.	0.46 mm.	left

Locality and level of hypotypes.-- Qu'Appelle Valley section (Figure 11), from clay unit 120 feet below the surface.

Distribution.-- The species occurs in the Qu'Appelle Valley section at levels of 130, 125, 120, 105, 100, and 20 feet below the surface.

The author has observed the species in the Sturgeon Lake marl deposit and Waskana Lake, Saskatchewan.

Hypotypes.-- Geological Museum, University of Saskatchewan.

Family EUCANDONIDAE, Swain, 1961

Genus EUCANDONA Daday, 1900

EUCANDONA CAUDATA (Kaufmann), 1900

Plate 4, figures 8-9

Candona caudata Kaufmann, 1900, Rev. Suisse Zool. no. 8, p. 365-368, pl. 24, figs. 16-20; pl. 26, figs. 17-23.

Candona caudata Kaufmann. Hoff, 1942, Illinois Biol. Mon., v. 19, no. 1-2, p. 80-82, pl. 3, figs. 33-35 (synonymy).

Shell reniform in side view, acutely pointing in anterior region in dorsal view. Dorsal margin strongly convex; ventral margin concave; anterior margin broadly rounded; posterior margin very narrow, evenly rounded; posterior cardinal angle obtuse. Shell surface smooth, transparent to translucent.

Left valve larger than right valve with complete overlap. Adductor muscle scar forms rosette pattern composed of five suboval depressions anterior of central region; two mandibular scars anteroventral from rosette; one suboval antennal scar anterodorsal from adductor muscle scar.

Duplicature moderately developed; vestibules moderately well developed, anterior vestibule with inner margin semicircular in outline, posterior vestibule extends onto ventral margin giving inner margin angulate outline.

Measurements of hypotypes.--

	Length	Height	Valve
female:	1.25 mm.	0.62 mm.	right G.M.U.S.-Ao-8 (fig. 8)
	1.17 mm.	0.58 mm.	left G.M.U.S.-Ao-9 (fig. 9)

Locality and level of hypotypes.-- Rocky Lake Section (Figure 8), from silty clay unit 8 feet beneath the top of the lower lacustrine unit.

Distribution.-- The figured specimens mark the only occurrence of this species in the study area.

Hypotypes.-- Geological Museum, University of Saskatchewan.

EUCANDONA FOSSULENSIS (Hoff), 1942

Plate 4, Figure 10

Candona fossulensis Hoff, 1942, Illinois Biol. Mon., v. 19, no. 1-2, p. 92, pl. 5, figs. 58-64.

Candona fossulensis Hoff. Winkler, 1960, Jour. Palaeontology, v. 34, no. 5, p. 925, pl. 122, figs. 10-13.

Shell subrectangular to reniform in side view, acutely pointing in anterior region in dorsal view. Dorsal margin convex; ventral margin concave; anterior margin subrounded to square; posterior margin rounded, greatest curvature approaching dorsal margin, acute posterior cardinal angle. Shell surface smooth, transparent to translucent.

Right valve larger than left valve with complete overlap. Adductor muscle scar forms rosette composed of five suboval depressions anterior of central region; two mandibular scars anteroventral from adductor muscle scar.

Duplicature extremely narrow; line of concrescence well defined; anterior vestibule well developed with inner margin crescentic in outline;

posterior vestibule weakly developed with inner margin subcrescentic in outline.

Measurements of hypotypes.--

	Length	Height	Valve
female?:	0.89 mm.	0.50 mm.	right G.M.U.S.-Ao-10 (fig. 10)

Locality and level of hypotype.-- Qu'Appelle Valley section (Figure 11) from clay unit 120 feet below the surface.

Distribution.-- The figured specimen marks the only occurrence of the species in the study area.

Hypotype.-- Geological Museum, University of Saskatchewan.

EUCANDONA OHIOENSIS (Furtos), 1933

Plate 4, figure 11

Candona ohioensis Furtos, 1933, Ohio Biol. Survey, v. 5, pl. 9, fig. 1, pl. 10, figs. 8-12.

Candona ohioensis Furtos. Staplin, 1953, microfilmed unpublished Ph.D. Thesis, University of Illinois.

Shell very elongate, slipper-shaped in side view, acutely pointing in anterior region in dorsal view. Dorsal margin evenly arched; posterior margin narrower than anterior, broadly rounded; ventral margin concave. Shell surface smooth, shows polygonal pattern from interior, transparent to translucent.

Left valve larger than right valve, partial overlap on dorsal and ventral sides; dorsal edge of left valve with receptacle for bar of right valve. Adductor muscle scar forms rosette composed of five suboval depressions anterior of central region; two mandibular scars anteroventral from rosette; one antennal scar anterodorsal from adductor muscle scar.

Duplicature poorly developed with few radial pore canals; lateral extension of duplicature anterior and posterior of bar-groove in left valve forms a flap, right valve without flap but shell is displaced inward where flap from left valve fits to allow for mobilization; line of concrescence weak; vestibule in anterior region well developed with inner margin crescentic in outline.

Measurements of hypotype.--

	Length	Height	Valve
male:	1.83 mm.	0.87 mm.	left G.M.U.S.-Ao-11 (fig. 11)

Locality and level of hypotype.-- Qu'Appelle Valley section (Figure 11) from clay unit 105 feet below the surface.

Distribution.-- The species occurs in the Qu'Appelle Valley section at levels of 115 and 105 feet below the surface.

Hypotype.-- Geological Museum, University of Saskatchewan.

EUCANDONA POSEYENSIS (Staplin), 1960

Plate 4, figure 12

Candona poseyensis Staplin. Winkler, 1960, Jour. Palaeontology, v. 34, no. 5, p. 926, pl. 122, figs. 13-17.

Shell reniform in side view acutely pointing in anterior region in dorsal view. Dorsal margin strongly convex; ventral margin concave; posterior and anterior margins broadly rounded, greatest curvature approaching dorsal margin. Shell surface smooth, translucent to transparent.

Right valve larger than left valve with complete overlap. Adductor muscle scar forms rosette composed of five suboval depressions anterior

of central region. Two mandibular scars anteroventral from adductor muscle scar, one antennal scar anterodorsal from adductor muscle scar.

Duplicature extremely narrow; line of concrescence well defined; vestibules moderately well developed, anterior vestibule with inner margin semicircular in outline, posterior vestibule with inner margin crescentic in outline.

Measurements of hypotype.--

	Length	Height	Valve
female?:	1.10 mm.	0.58 mm.	right G.M.U.S.-Ao-17 (fig. 12)

Locality and level of hypotype.-- Qu'Appelle Valley section (Figure 11) from clay unit 120 feet below the surface.

Distribution.-- The figured specimen marks the only occurrence of this species in the study area.

Hypotype.-- Geological Museum, University of Saskatchewan.

EUCANDONA SWAINI Staplin, n. sp.

Plate 4, figure 13-17

Candona sp. of Swain, 1947, Jour. Palaeontology, v. 21, no. 6, p. 518-528, pl. 76-77.

Candona swaini (Staplin), 1953, microfilmed unpublished Ph.D. thesis, University of Illinois.

Shell elongate, reniform in side view, acutely pointing to slightly rounded in anterior region in dorsal view. Dimorphism strongly exhibited, males much larger, posterior more bulbous. Dorsal margin strongly arched; ventral margin gently concave except in male where anterior curvature meets ventral edge; anterior margin of both female

and male evenly rounded; posterior margin of male evenly rounded, greatest curvature approaching dorsum; posterior margin of right valve of female similarly rounded butcardinal angle more acute, posterior margin of left valve forms a right angle with dorsum where flange-like extension is produced. Shell surface smooth, translucent to transparent.

Left valve larger than right valve with complete overlap. Adductor muscle scar forms rosette composed of five suboval depressions just anterior of central region; two mandibular scars anteroventral from rosette; one antennal scar anterodorsal from adductor muscle scar.

Duplicature well formed with many radial pore canals, forming square lip in posterior region of left valve of female; well defined line of concrescence; anterior vestibule well developed with inner margin semicircular in outline; posterior vestibule incipiently formed with inner margin crescentic in outline.

Measurements of types.--

		Length	Height	Valve	
female,	holotype:	1.17 mm.	0.67 mm.	right	G.M.U.S.-Ao-13 (fig. 13)
	paratype:	1.17 mm.	0.62 mm.	left	G.M.U.S.-Ao-14 (fig. 14)
male,	paratype:	1.21 mm.	0.67 mm.	right	G.M.U.S.-Ao-15 (fig. 15)
	paratype:	1.25 mm.	0.69 mm.	left	G.M.U.S.-Ao-16 (fig. 16)
female carapace	paratype:	1.17 mm.	0.67 mm.	right	G.M.U.S.-Ao-17 (fig. 17)
		1.25 mm.	0.69 mm.	left	

Type locality.-- Rocky Lake section (Figure 8) from silty clay unit nine feet from the top of the lower lacustrine unit. The female carapace (Figure 17) is from Waskana Lake.

Distribution.-- Occurs in all of the disintegrated clay samples that contained ostracods from the Rouleau Basin section (Figure 10), Qu'Appelle Valley section (Figure 11), and Rocky Lake section (Figure 8).

Types.-- Geological Museum, University of Saskatchewan.

Remarks.-- Staplin named and described this species in his thesis.

EUCANDONA SP. A

Plate 4, figure 18

Shell subreniform to subtriangular in side view, acutely pointing in anterior region in dorsal view. Dorsal margin convex; ventral margin concave; anterior margin broadly rounded; postero-dorsal margin nearly straight, approaches ventral margin at acute angle of 45°. Shell surface smooth, translucent to transparent.

Right valve larger than left valve with complete overlap; prominent flap developed near ventral end of posterodorsal slope, curved in toward interior. Adductor muscle scar forms rosette pattern composed of five suboval depressions anterior of central region; two mandibular scars anteroventral from rosette; one antennal scar antero-dorsal from adductor muscle scar.

Duplicature very narrow; line of concrescence well defined; vestibules moderately well developed, anterior vestibule with inner margin semicircular in outline, posterior vestibule extends to ventral margin giving inner margin angulate outline.

Measurements of figured specimen.--

	Length	Height	Valve
female:	1.12 mm.	0.75 mm.	right G.M.U.S.-Ao-18 (fig. 18)

Locality and level of figured specimen.-- Qu'Appelle Valley section (Figure 11) from clay unit 120 feet below the surface.

Distribution.-- The figured specimen marks the only occurrence of this species. This species is abundant in the Sturgeon marl deposit. The present author also obtained this species from Waskana Lake, Saskatchewan.

Figured specimen.-- Geological Museum, University of Saskatchewan.

Remarks.-- This species resembles Eucandona crogmaniana (Turner) except that the length-height ratio is smaller indicating a greater height for Eucandona sp. A. The flap on the posterodorsal slope is much lower in Eucandona sp. A than Eucandona crogmaniana.

Family ILYOCYPRIDIDAE Kaufmann, 1900

Subfamily ILYOCYPRIDINAE Kaufmann, 1900

Genus ILYOCYPRIS Brady and Norman, 1889

ILYOCYPRIS BRADYI Sars, 1890

Plate 5, figures 1-2

Ilyocypris bradyi Sars, 1890, Arter. Forh. Seldk. Christian., p. 59-60.

Ilyocypris bradyi Sars. Hoff, 1942, Illinois Biol. Mon., v. 19, no. 1-2, p. 130-131, pl. 7, figs. 101-102.

Shell subrectangular in side view, acutely pointing in anterior region in dorsal view. Dimorphism not known. Dorsal margin nearly straight, slightly convex; ventral margin with pronounced mid-ventral sinuation; anterior margin broadly rounded; posterior margin broadly rounded, dorsal edge meets posterior margin at obtuse angle. Shell surface bears major and minor sulci; major sulcus extends from dorsal edge down to mid-point on carapace; minor sulcus anterior of major sulcus, not

as long, incipiently developed; flanks of sulci moderately steep. Surface of shell punctate, translucent to transparent.

Left valve slightly larger than right valve, contains groove and flange along dorsal edge. Adductor muscle scar consists of cluster of four suboval depressions on boss made by mid-areal portion of major sulcus; two mandibular scars anteroventral of adductor scar on lower extremity of minor sulcus, anterior of adductor scar.

Duplicature narrow, well formed with many radial pore canals; line of concrescence well defined; vestibule weakly developed with inner margin semicircular in outline; posterior margin ornamented by tubercles.

<u>Measurements of hypotypes</u>.--

	Length	Height	Valve
female:	0.92 mm.	0.50 mm.	right G.M.U.S.-Ao-19 (fig. 1)
	0.92 mm.	0.52 mm.	left G.M.U.S.-Ao-20 (fig. 2)

<u>Locality and level of hypotypes</u>.-- Qu'Appelle Valley section (Figure 11) from clay unit 55 feet below the surface.

<u>Distribution</u>.-- The species occurs sporadically through the Qu'Appelle Valley section and the Rouleau Basin. It was also found in Waskana Lake, Saskatchewan.

<u>Hypotypes</u>.-- Geological Museum, University of Saskatchewan.

ILYOCYPRIS GIBBA (Ramdohr), 1808

Plate 5, figures 3-4

<u>Cypris gibba</u> Ramdohr, 1808, Arter. Mag. Ges. Fr. Berlin, v. 2, p. 91, pl. 3, figs. 13-14, 17.

<u>Ilyocypris gibba</u> (Ramdohr). Hoff, 1942, Illinois Biol. Mon., v. 19, no.1-2, p. 128, pl. 7, figs. 99-100.

Shell subrectangular in side view, acutely pointing in anterior region in dorsal view. Dorsal margin nearly straight, slightly convex; ventral margin with pronounced mid-ventral sinuation; anterior margin broadly rounded; posterior margin broadly rounded, dorsal edge meets posterior margin at obtuse angle. Shell surface bears three lateral projections, major and minor sulci; most prominent ala posterior of mid-dorsal area, a second ala anterodorsal of median area between major and minor sulci, a third alate node anterior of minor sulcus; major sulcus extends from dorsal edge down to mid-point of carapace; minor sulcus anterior of major sulcus, not as long, incipiently developed; flanks of sulci moderately steep. Surface of shell punctate, translucent to transparent.

Left valve slightly larger than right valve, contains groove and flange along dorsal edge. Adductor muscle scar consists of cluster of four suboval depressions on boss made by mid-areal portion of major sulcus; two mandibular scars anteroventral of adductor scar; antennal scar on lower extremity of minor sulcus, anterior of adductor scar.

Duplicature well formed with many radial pore canals, surface slopes toward interior; line of concrescence well defined; anterior vestibule weakly developed with inner margin semicircular in outline; posterior margin ornamented by tubercles.

Measurements of hypotypes.--

	Length	Height	Valve
female:	0.94 mm.	0.48 mm.	right G.M.U.S.-Ao-21 (fig. 3)
	0.94 mm.	0.52 mm.	left G.M.U.S.-Ao-22 (fig. 4)

Locality and level of hypotypes.-- Rouleau Basin section (Figure 10) from clay unit 14 feet below surface.

<u>Distribution</u>.-- The species occurs sporadically through the Qu'Appelle Valley section and the Rouleau Basin section. It was also found in Waskana Lake, Saskatchewan.

<u>Hypotypes</u>.-- Geological Museum, University of Saskatchewan.

Superfamily CYTHERACEA Baird, 1850

Family CYTHERIDEIDAE Sars, 1925

Subfamily NEOCYTHERIDEIDINAE Puri, 1957

Genus CYTHERISSA Sars, 1925

CYTHERISSA LACUSTRIS Sars, 1863

Plate 5, figures 5-6

<u>Cytherissa</u> <u>lacustris</u> Sars, 1893, Nytt Mag. Naturvidenskenskapens, v. 12, p. 22.

Shell subquadrate to subrectangular in side view, rounded to acutely pointing in anterior region in dorsal view. Dorsal margin straight; ventral margin nearly straight, slight ventral sinuation; anterior margin broader than posterior margin, both evenly rounded. Shell surface bears five very low nodes, most prominent node anteromedian, other nodes as follows; mid-dorsal-anterodorsal, mid-dorsal-posterodorsal, anteroventral, posteroventral. Surface of shell smooth, spotted with clusters of normal pore canals; translucent.

Valves nearly equal in size; right valve contains long groove with teeth at either end, valve edge recessed from posterior tooth around posterior region along ventral margin and continues incipiently around anterior margin; left valve contains bar with posterior and anterior teeth, dorsal margin of valve extended as flange to fit recess

in dorsal margin of right valve. Scars located around most prominent node anterior of central area slightly ventral; adductor scar on posterior edge of anteromedian depression, consists of four loosely knitted suboval scars in row perpendicular to hinge line; one mandibular scar anteroventral of adductor muscle scar on edge of anteroventral depression; antennal scar anterodorsal of adductor muscle scar on edge of depression formed by mid-dorsal-anterodorsal node.

Duplicature evenly developed with well developed widely spaced radial pore canals.

Measurements of hypotypes.--

	Length	Height	Valve
female:	0.87 mm.	0.54 mm.	right G.M.U.S.-Ao-23 (fig. 5)
	0.89 mm.	0.54 mm.	left G.M.U.S.-Ao-24 (fig. 6)

Locality and level of hypotypes.-- Rocky Lake section (Figure 8) from silty clay unit 3 feet from the top of the lower lacustrine unit.

Distribution.-- This species occurs sporadically through the Qu'Appelle Valley section, Rocky Lake section and the Rouleau Basin section. It was not found in any of the lakes investigated by the author outside the study area.

Hypotypes.-- Geological Museum, University of Saskatchewan.

Family LIMNOCYTHERIDAE Klie, 1938

Genus LIMNOCYTHERE Brady, 1868

LIMNOCYTHERE SP. A. Delorme, n. sp.

Plate 5, figures 7-10

Shell subrectangular in side view. Dorsal margin straight; ventral margin slightly concave, anteroventral sinuation poorly developed;

anterior margin broadly rounded; posterior margin convex, posterodorsal angle obtuse. Shell surface bears two sulci and one ala; mid-ventral ala prominent, very pointed; major sulcus mid-dorsal to central, has gentle slopes, extends down two-thirds height of shell from mid-dorsum, trough not even; minor sulcus anterior of and not as long as major sulcus, poorly developed. Surface of shell prominently reticulate; transparent to translucent.

Right valve contains dorsal groove to accommodate bar of left valve. Major sulcus represented in interior by small ridge that bears four oval adductor muscle scars aligned perpendicular to hinge; one mandibular scar located anteroventral of adductor scar; antennal scars anterodorsal from adductor muscle scar.

Hyaline border present but indistinct from outer lamella, more transparent.

Measurements of types.--

		Length	Height	Valve
female,	holotype:	0.62 mm.	0.29 mm.	right G.M.U.S.-Ao-25 (fig. 7)
	paratype:	0.65 mm.	0.31 mm.	left G.M.U.S.-Ao-26 (fig. 8)
male,	paratype:	0.71 mm.	0.33 mm.	right G.M.U.S.-Ao-27 (fig. 9)
	paratype:	0.69 mm.	0.33 mm.	left G.M.U.S.-Ao-28 (fig. 10)

Type locality.-- Sturgeon Lake, Saskatchewan from shore marl.

Distribution.-- This species occurs in the Qu'Appelle Valley section at a level of 110 feet below the surface and 4 feet from the surface in the Rouleau Basin section. The Sturgeon marl deposit contains this species in considerable abundance.

Types.-- Geological Museum, University of Saskatchewan.

Remarks.-- This species does not resemble any other limnocytherean previously described. Its mid-ventral ala and posterodorsal slope are characteristic.

LIMNOCYTHERE SP. B Delorme, n. sp.

Plate 5, figures 11-14

Shell subrectangular in side view. Dimorphism exhibited. Dorsal margin straight; ventral margin concave, prominent sinuation anterior of central ventral position; anterior margin broadly rounded; posterior margin acute to subrounded. Shell surface bears two sulci and four alae; major sulcus mid-dorsal to central area, extends down two-thirds height of shell; minor sulcus anterior of major sulcus, incipiently developed, flanks of sulci steep; most anterior ala anterior of minor sulcus in central region; second ala anteromedian, at base of inter-sulci ridge; third ala dorsomedian, posterior of major sulcus; fourth ala, most prominent, posteroventral of major sulcus. Surface of shell reticulate, translucent to transparent.

Left valve contains straight bar which fits into groove of right valve. Major sulcus represented in interior by small ridge that bears four oval adductor muscle scars aligned perpendicular to hinge; one mandibular scar anteroventral of adductor scar, antennal scars anterodorsal from adductor muscle scar.

Hyaline border present in anterior, anteroventral and posteroventral areas, broad, contains radial pore canals.

Measurements of types.--

		Length	Height	Valve		
female,	holotype:	0.78 mm.	0.46 mm.	right	G.M.U.S.-Ao-29	(fig. 11)
	paratype:	0.81 mm.	0.46 mm.	left	G.M.U.S.-Ao-30	(fig. 12)
male,	paratype:	0.78 mm.	0.42 mm.	right	G.M.U.S.-Ao-31	(fig. 13)
	paratype:	0.81 mm.	0.40 mm.	left	G.M.U.S.-Ao-32	(fig. 14)

Type locality.-- Qu'Appelle Valley section (Figure 11) from clay unit 20 feet below the surface.

Distribution.-- The species occurs in the Qu'Appelle Valley section at levels of 20 and 10 feet below the surface.

Types.-- Geological Museum, University of Saskatchewan.

Remarks.-- This species does not resemble any other limnocytherean previously described. The four prominent alae make it very distinct.

LIMNOCYTHERE SP. C Delorme, n. sp.

Plate 5, figures 15-18

Shell subrectangular in side view. Dimorphism exhibited. Dorsal margin convex; ventral margin with pronounced sinuation in mid-ventral position; anterior margin broadly rounded, greatest curvature approaching dorsal margin. Shell surface bears two sulci; major sulcus extends from dorsal margin down two-thirds height of shell; flanks of sulcus steep, may or may not be bordered in mid-dorsal position by small node; minor sulcus ventral of node and anterior of major sulcus. Surface of shell prominently reticulate except on node and in sulci; shell translucent.

Left valve contains convexly curved bar which fits into groove of right valve. Major sulcus represented in interior by small ridge that bears muscle scars; row of four oval adductor scars perpendicular to dorsal edge; one mandibular scar located anteroventral of adductor scar, antennal scars anterodorsal of adductor scar.

Hyaline border weakly developed, surfaces sloping towards interior, female may be without inner lamellae. Spines or tubercles may protrude from hyaline border in posteroventral position.

Measurements of types.--

		Length	Height	Valve
female,	holotype:	0.54 mm.	0.29 mm.	right G.M.U.S.-Ao-33 (fig. 15)
	paratype:	0.54 mm.	0.29 mm.	left G.M.U.S.-Ao-34 (fig. 16)
male,	paratype:	0.58 mm.	0.33 mm.	right G.M.U.S.-Ao-35 (fig. 17)
	paratype:	0.58 mm.	0.33 mm.	left G.M.U.S.-Ao-36 (fig. 18)

Type locality.-- Rocky Lake section (Figure 8) from silty clay unit 9 feet beneath the top of the lower lacustrine unit.

Distribution.-- This species occurs throughout the lacustrine units of the Rocky Lake section, restricted above and below the high sulphate zone in the Rouleau Basin section and is sporadic in its occurrence in the Qu'Appelle Valley section.

Types.-- Geological Museum, University of Saskatchewan.

Remarks.-- This species has a similar appearance to *Limnocythere reticulata* Sharpe and *L. illinoisensis* Sharpe. Both of these species are much longer than *L.* sp. C and have different shell sculpture.

LIMNOCYTHERE SP. D Delorme, n. sp.

Plate 5, figures 19-22

Shell subrectangular in side view. Dimorphism exhibited, males more elongate. Dorsal margin straight; ventral margin nearly straight except for curvature of ventral sinuation; anterior margin broadly and evenly rounded; posterior margin broadly rounded, greatest curvature approaching dorsal margin. Shell surface interrupted by ventral ridge,

major and minor sulcus; ridge extends total length of ventral margin, best developed dorsal of ventral sinuation; deflated area ventral of dorsal margin extends from mid-dorsal to anterodorsal area; in mid-dorsal area it continues ventrally two-thirds height of shell joining major sulcus; minor sulcus anterior of major sulcus incipiently developed; flanks of sulci steep. Surface of shell smooth but shows faint polygonal pattern, translucent, heavily calcified, thick.

Dentition consists of bar and sockets in left valve, groove and teeth in right valve. Adductor muscle scar anterior of central area, consists of row of four suboval depressions oriented perpendicular to hinge; two mandibular scars anteroventral from adductor scar; three antennal scars anterodorsal of adductor scar.

Hyaline border weakly developed with few bifurcating radial pore canals visible.

Measurements of types.--

		Length	Height	Valve	
female,	holotype:	0.65 mm.	0.37 mm.	right	G.M.U.S.-Ao-37 (fig. 19)
	paratype:	0.69 mm.	0.35 mm.	left	G.M.U.S.-Ao-38 (fig. 20)
male,	paratype:	0.78 mm.	0.33 mm.	right	G.M.U.S.-Ao-39 (fig. 21)
	paratype:	0.77 mm.	0.33 mm.	left	G.M.U.S.-Ao-40 (fig. 22)

Type locality.-- Rocky Lake section (Figure 8) from silty clay 3 feet beneath the top of the upper lacustrine unit.

Distribution.-- This species occurs only in the upper lacustrine unit in the Rocky Lake section.

Types.-- Geological Museum, University of Saskatchewan.

Remarks.-- This species does not resemble any other limnocytherean previously described.

LIMNOCYTHERE SP. E

Plate 5, figure 23

Shell subrectangular to box-like in side view. Dorsal margin slightly convex; ventral margin concave; anterior margin broadly rounded, offset towards ventral edge; posterior margin broadly rounded, greatest curvature approaching dorsal edge. Shell surface bears distinct sulci and one low node; major sulcus extends ventrally two-thirds height of shell from dorsal edge; minor sulcus anterior of major sulcus does not extend as far ventrally; two sulci flare out dorsad, reentrant of flared sulci guarded by low node; major and minor sulci connected ventral of node, flanks of sulci extremely steep. Surface of shell flattened, forms right angle to ventral, posterior and dorsal margin; surface pattern distinctively polygonal, center of each polygon position of normal pore canal, shell translucent to transparent.

Left valve contains convexly curved bar which fits into groove of right valve. Major sulcus represented in interior by ridge that bears on its ventral extremity four suboval adductor scars perpendicular to hinge; one mandibular scar anteroventral of adductor scar; antennal scar on ridge formed by minor sulcus anterodorsal from adductor scars.

Duplicature well formed in anteroventral area with radial pore canals.

Measurements of figured specimen.--

	Length	Height	Valve	
female?:	0.56 mm.	0.29 mm.	right	G.M.U.S.-Ao-43 (fig. 23)
	0.58 mm.	0.33 mm.	left	unfigured

Locality and level of figured specimen.-- Rocky Lake section (Figure 8) from silty clay 2 feet from top of the upper lacustrine unit.

Distribution.-- The figured specimen marks the only occurrence of this species in the study area.

Figured specimen.-- Geological Museum, University of Saskatchewan.

Remarks.-- This species is similar to *Limnocythere* sp. C except for the flattened surface of the shell and the very distinctive polygonal pattern. In this latter respect it is also similar to *L. reticulata* Sharpe.

LIMNOCYTHERE SP. F Delorme, n. sp.

Plate 5, figures 24-25

Shell subrectangular in side view. Dorsal margin straight; ventral margin sinuous; anterior margin broadly rounded, greatest curvature approaching dorsal edge; posterior margin broadly rounded. Shell surface bears two sulci; major sulcus extends two-thirds height of shell from dorsal edge; minor sulcus anterior of major sulcus, incipiently developed; flanks moderately steep; posterodorsal region of shell inflated, gentle slope towards ventral edge. Surface of shell faintly reticulate.

Left valve contains straight bar which fits into groove of left valve. Major sulcus represented in interior by ridge that bears four suboval adductor muscle scars in a row perpendicular to hinge line; one mandibular scar located anteroventral of adductor scars; antennal scars anterodorsal from adductor muscle scars.

Hyaline border well developed in anterior, anteroventral, and posteroventral region with widely spaced radial pore canals.

Measurements of types.--

	Length	Height	Valve
female, holotype:	0.67 mm.	0.33 mm.	right G.M.U.S.-Ao-41 (fig. 24)
paratype:	0.67 mm.	0.33 mm.	left G.M.U.S.-Ao-42 (fig. 25)

Type locality.-- Rocky Lake section (Figure 8) from silty clay 9 feet beneath the top of the lower lacustrine unit.

Distribution.-- This species occurs in the bottom 5 feet of the lower lacustrine unit of the Rocky Lake section. Outside the study area it occurs in Lake Willowbunch.

Types.-- Geological Museum, University of Saskatchewan.

Remarks.-- This species is very similar to *Limnocythere reticulata* Sharpe and may be the same. It differs by having an inflated posterodorsal region, surface not prominently reticulate and hyaline border not well developed. No males were found associated with the females which may indicate that *L.* sp. F is a different species.

LIMNOCYTHERE SP. G Delorme, n. sp.

Plate 5, figures 26-29

Shell subquadrate in side view. Dimorphism well exhibited with males more elongate. In female, greatest height anterior; in male, greatest height posterior. Ventral margin concave with weakly developed sinuation in mid-ventral area; dorsal margin straight; anterior cardinal angle broadly obtuse; anterior margin broadly rounded, greatest curvature approaching dorsal margin. Surface of shell bears two sulci and two alae; major sulcus vertical, extends from dorsal margin ventrally two-thirds height of shell, flanks steep; minor sulcus anterior and dorsal of major sulcus, begins as prominent oval depression, continues weakly and flares

out at the dorsal margin, slopes anteroventrally; major and minor sulci divided by two low nodes forming an incipient ridge; ventral and dorsal surface expanded with oblique alae, posteroventrally and posterodorsally, greatest height of alae posterior of ventral sinuation. Surface of carapace faintly reticulate except on alae. Dorsal ala may be absent on female and has not been observed on male specimens.

Left valve contains bar which fits into recepticle of right valve. Major sulcus represented in interior by ridge that bears muscle scars; adductor scar consists of a row of four oval spots orientated perpendicular to dorsal edge; one mandibular scar anteroventral of adductor scars; three suboval antennal scars anterodorsal from adductor scar on ridge formed by minor sulcus.

Measurements of types.--

		Length	Height	Valve
female,	holotype:	0.58 mm.	0.33 mm.	right G.M.U.S.-Ao-43 (fig. 26)
	paratype:	0.58 mm.	0.33 mm.	left G.M.U.S.-Ao-44 (fig. 27)
male,	paratype:	0.71 mm.	0.37 mm.	right G.M.U.S.-Ao-45 (fig. 28)
	paratype:	0.71 mm.	0.42 mm.	left G.M.U.S.-Ao-46 (fig. 29)

Type locality.-- Rocky Lake section (Figure 8) from silty clay 10 feet beneath the top of the lower lacustrine unit.

Distribution.-- This species occurs in the lower lacustrine unit of the Rocky Lake section as well as in the Rouleau Basin and Qu'Appelle Valley sections. This species also occurs in Old Wives Lake and Willowbunch Lake outside the study area.

Types.-- Geological Museum, University of Saskatchewan.

Remarks.-- This species does not resemble any other limnocytherean previously described.

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APPENDIX

Pleistocene Section

Section 1.--Section in a test-hole in the NE corner of Sec. 30, Tp. 14, Rge. 23, W.22nd Mer.

Deposit	Sample no. and depth (feet)
ROULEAU CLAY	
Clay, calcareous, dark grey (5Y4/1* wet), unoxidized, massive.	3
Clay, calcareous, dark grey (5Y4/1 wet), unoxidized, massive.	4
Clay, calcareous, dark grey (5Y4/1 wet), unoxidized, massive.	5
Clay, calcareous, very dark greyish brown (2.5Y3/2 wet), unoxidized, carbonaceous, massive.	6
Clay, calcareous, very dark greyish brown (2.5Y3/2 wet), unoxidized, selenite present.	7
Clay, calcareous, dark grey (5Y4/1 wet), unoxidized, selenite present.	8
Clay, calcareous, dark grey (5Y4/1 wet), unoxidized, selenite present.	9
Clay, calcareous, very dark grey (5Y3/1 wet), unoxidized.	10
Clay, calcareous, very dark grey (5Y3/1 wet), unoxidized, selenite present in tubes.	11
Clay, calcareous, black (5Y2/1 wet), unoxidized, selenite present.	12
Clay, calcareous, very dark grey (5Y3/1 wet), unoxidized.	13
CONDIE CLAY	
Clay, calcareous, very dark grey (10YR3/1 wet), oxidized.	14
Clay, calcareous, very dark greyish brown (10YR3/2 wet), oxidized, selenite present.	15

* From Munsell Colour Chart

Clay, calcareous, very dark grey (10YR3/1 wet), oxidized. 16

Clay, calcareous, very dark greyish brown (10YR3/2 wet), oxidized, selenite present. 17

Clay, calcareous, very dark greyish brown (10YR3/2 wet), oxidized selenite present. 18

REGINA CLAY

Clay, calcareous, very dark greyish brown (10YR3/2 wet), oxidized, carbonates, sulphates present, carbonaceous. 19

Clay, calcareous, very dark greyish brown (10YR3/2 wet), oxidized, selenite present, carbonaceous. 20

Clay, calcareous, very dark greyish brown (10YR3/2 wet), oxidized, selenite present, carbonaceous. 21

Clay, calcareous, very dark greyish brown (10YR3/2 wet), oxidized, slightly carbonaceous. 22

Clay, calcareous, very dark greyish brown (10YR3/2 wet). 23

Clay, calcareous, dark yellowish brown (10YR3/4 wet), oxidized, slightly carbonaceous. 24

MOOSE JAW CLAY

Clay, slightly calcareous, dark greyish brown to dark yellowish brown (10YR4/2-4/4 wet), oxidized, carbonaceous. 25

Clay, calcareous, dark greyish brown (10YR4/2 wet), oxidized, carbonaceous. 26

Clay, calcareous, very dark greyish brown (10YR3/2 wet), oxidized, selenite present, carbonaceous. 27

Clay, calcareous, very dark grey (10YR3/1 wet), oxidized. 28

Clay, calcareous, very dark grey (10YR3/1 wet), oxidized. 29

Clay, calcareous, very dark greyish brown (10YR3/2 wet), oxidized. 30

Section 2.--Section in test-hole in the SE corner of Sec. 22, Tp. 13, Rge. 22, W.2nd Mer.

Deposit	Sample No. and depth (feet)
ROULEAU CLAY	
Clay, non-calcareous, black (5Y2/1 wet), unoxidized, carbonaceous.	1
Clay, calcareous, black (5Y2/1 wet), unoxidized, massive.	2
Clay, calcareous, very dark grey (5Y3/1 wet), unoxidized, massive.	3
Clay, calcareous, very dark grey (5Y3/1 wet), unoxidized, massive.	4
Clay, calcareous, very dark grey (5Y3/1 wet), unoxidized, massive.	5
Clay, calcareous, very dark grey (5Y3/1 wet), unoxidized, selenite present, massive.	6
Clay, calcareous, very dark grey (5Y3/1 wet), unoxidized, selenite present, massive.	7
Clay, calcareous, very dark grey (5Y3/1 wet), unoxidized, selenite present, massive.	8
Clay, calcareous, very dark grey (5Y3/1 wet), unoxidized, selenite present, massive.	9
Clay, calcareous, very dark grey (5Y3/1 wet), unoxidized, selenite present, massive.	10
Clay, calcareous, very dark greyish brown (2.5Y3/2 wet), oxidized, selenite present, massive.	11
Clay, calcareous, very dark grey (10YR3/1 wet), oxidized, selenite present, massive.	12
Clay, calcareous, very dark greyish brown (10YR3/2 wet), oxidized, selenite present, massive.	13
CONDIE CLAY	
Clay, calcareous, very dark greyish brown (10YR3/2 wet), oxidized, selenite present, massive.	14
Clay, calcareous, very dark greyish brown (10YR3/2 wet), oxidized, selenite abundant, massive.	15

Clay, calcareous, very dark greyish brown (10YR3/2 wet), oxidized, selenite present, massive. 16

Clay, calcareous, very dark greyish brown (10YR3/2 wet), oxidized, selenite present, massive. 17

Clay, calcareous, very dark greyish brown (10YR3/2 wet), oxidized, selenite present, massive. 18

Clay, calcareous, very dark greyish brown (10YR3/2 wet), oxidized, selenite present, massive. 19

REGINA CLAY

Clay, calcareous, very dark greyish brown (10YR3/2 wet), oxidized, selenite crystals very abundant, massive. 20

Clay, calcareous, very dark greyish brown (10YR3/2 wet), oxidized, carbonates present, carbonaceous, massive. 21

Clay, calcareous, very dark greyish brown (10YR3/2 wet), oxidized, massive. 22

Clay, calcareous, very dark greyish brown (10YR3/2 wet), oxidized, massive. 23

MOOSE JAW CLAY

Clay, calcareous, very dark greyish brown (10YR3/2 wet), oxidized, selenite crystals 3/4 inch diameter, massive. 24

Clay, calcareous, very dark greyish brown (10YR3/2 wet), oxidized, carbonaceous, massive. 25

Clay, calcareous, very dark greyish brown (10YR3/2 wet), oxidized, carbonaceous, massive. 26

Clay, calcareous, very dark greyish brown (10YR3/2 wet), oxidized, massive. 27

Clay, calcareous, very dark greyish brown (10YR3/2 wet), oxidized, massive. 28

Clay, calcareous, very dark greyish brown (10YR3/2 wet), oxidized, massive. 29

Clay, calcareous, very dark greyish brown (10YR3/2 wet), oxidized, massive. 30

Section 3.--NE corner L.S. 16, Sec. 10, Tp. 14, Rge. 23, W. 2nd Mer., Elevation -- 1864.

Deposit	Sample No. and depth (feet)
ROULEAU CLAY	
Clay, non-calcareous, black (5YR2/1 wet), clay loam, massive.	1
Clay, calcareous, black (5YR2/1 wet), unoxidized, massive.	2
Clay, calcareous, very dark grey (5Y3/1 wet), unoxidized, massive.	3
Clay, calcareous, very dark grey (5Y3/1 wet), unoxidized, massive.	4
Clay, calcareous, very dark grey (5Y3/1 wet), unoxidized, massive.	5
Clay, calcareous, very dark grey (5Y3/1 wet), unoxidized, massive.	6
Clay, calcareous, dark grey (5Y3/1 wet), unoxidized, massive.	7
Clay, calcareous, dark grey (5Y4/1 wet), unoxidized, massive.	8
Clay, calcareous, very dark grey (5Y3/1 wet), unoxidized, massive.	9
Clay, calcareous, very dark grey (10YR3/2 wet), unoxidized, massive, organic material.	10
Clay, calcareous, very dark grey (10YR3/2 wet), unoxidized, massive.	11
Clay, calcareous, very dark grey (10YR3/2 wet), unoxidized, becoming silty, massive.	12
Clay, calcareous, dark greyish brown (2.5Y4/2 wet), unoxidized, silty, selenite grains present, massive.	13
Silty clay, calcareous, dark greyish brown (2.54Y/2 wet), unoxidized, selenite grains present, massive.	14

Silty clay, calcareous, very dark greyish brown (2.5Y3/2 wet), unoxidized, selenite grains present, massive.	15
Silty clay, calcareous, very dark greyish brown (2.5Y3/2 wet), unoxidized, selenite grains present, massive.	16

Section 4.--SE corner Sec. 4, Tp. 14, Rge. 23, W. 2nd Mer., Elevation -- 1866.

Deposit	Sample No. and depth (feet)
ROULEAU CLAY	
Clay, calcareous (5Y3/1 wet), very dark grey, unoxidized, massive.	1
Clay, calcareous, black, (5Y2/1 wet), unoxidized, massive.	2
Clay, calcareous, black (5Y2/1 wet), unoxidized, organic material present, selenite present, massive.	3
Clay, calcareous, black (5Y2/1 wet), unoxidized, organic material present, massive.	4
Clay, calcareous, very dark grey (5Y3/2 wet), unoxidized, massive.	5
Clay, calcareous, very dark grey (5Y3/2 wet), unoxidized, massive.	6
Clay, calcareous, very dark grey (5Y3/1 wet), unoxidized, white material present possibly selenite?, massive.	7
Clay, calcareous, very dark grey (5Y3/1 wet), unoxidized, selenite present, massive.	8
Clay, calcareous, very dark grey (5Y3/1 wet), unoxidized, organic material present, massive.	9
Clay, calcareous, very dark greyish brown (10YR3/2 wet), unoxidized, extremely high selenite content, massive.	10

Clay, calcareous, very dark greyish brown (10YR3/2 wet), unoxidized, selenite content high, sediment not homogeneous colour, massive.	11
Clay, calcareous, very dark greyish brown (10YR3/2 wet), unoxidized, selenite present, heterogenous colour, massive.	12
Silt, calcareous, very dark greyish brown (2.5Y3/2 wet), unoxidized, appears as a silty clay, selenite present, massive.	13
Silt, calcareous, very dark greyish brown, oxidized, bands of iron oxide staining, selenite present, massive.	14
Silt, calcareous, very dark greyish brown (2.5Y3/2 wet), unoxidized, massive.	15

Section 5.--SE corner, Sec. 24, Tp. 14, Rge. 23, W. 2nd Mer., Elevation -- 1871.

Deposit	Sample No. and depth (feet)
ROULEAU CLAY	
Clay, calcareous, very dark grey (5Y3/1 wet), unoxidized, massive.	1
Clay, calcareous, dark olive grey, (5Y3/2 wet), unoxidized, massive.	2
Clay, calcareous, very dark grey (5Y3/1 wet), unoxidized, massive.	3
Clay, calcareous, very dark grey (5Y4/1 wet), unoxidized, massive.	4
Clay, calcareous, very dark grey (5Y3/1 wet), unoxidized, massive.	5
Clay, calcareous, very dark grey (5Y3/1 wet), unoxidized, massive.	6
Clay, calcareous, very dark grey (5Y3/1 wet), unoxidized, massive.	7
Clay, calcareous, very dark grey (5Y3/1 wet), unoxidized, massive.	8

Clay, calcareous, dark olive grey (5Y3/2 wet), unoxidized, massive, clay is darker.	9
Clay, calcareous, dark olive grey (5Y3/2), unoxidized, massive.	10
Silty clay, calcareous, very dark greyish brown (2.5 Y3/2 wet), unoxidized, selenite present, massive.	11
Silt, calcareous, very dark greyish brown (2.5Y3/2 wet), unoxidized, massive.	12
Silt, calcareous, very dark greyish brown (2.5Y3/2 wet), unoxidized, massive.	13
Silt, calcareous, dark greyish brown (2.5Y4/2 wet), unoxidized, massive.	14
Silt, calcareous, very dark greyish brown (2.5Y3/2 wet), unoxidized, massive.	15

EXPLANATION OF PLATE 1

Gypsum crystals from the Regina Basin

Figure

1. Core showing gypsum grains in tubes in Rouleau Clay, magnification X 2/3. (SE corner, Sec. 22, Tp. 13, Rge 22, W. 2nd Mer.)

2-5 Selenite crystal from Chamberlain exposure, Section 9, Township 22, Range 26, W. 2nd Meridian.

2: top view showing disc like appearance, magnification X 2
3: lateral view, perpendicular to (010) face, shows lateral projections on top and bottom, magnification X 2
4: thin section perpendicular to (010) face, under crossed nicols, shows position of axes and composition plane, magnification X 3.3.
5: thin section under crossed nicols, shows "herring bone" pattern, magnification X 3.3.

6-7 Gypsum cluster from Chamberlain exposure

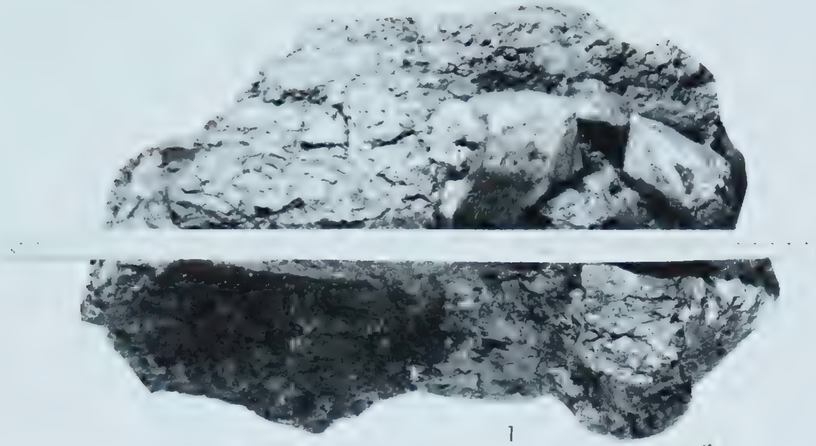
6: top view showing disc like appearance of individual crystals making up the cluster, magnification X 2.
7: bottom view showing hollow central region, magnification X 2.

PLATE I

EXPLANATION OF PLATE 2

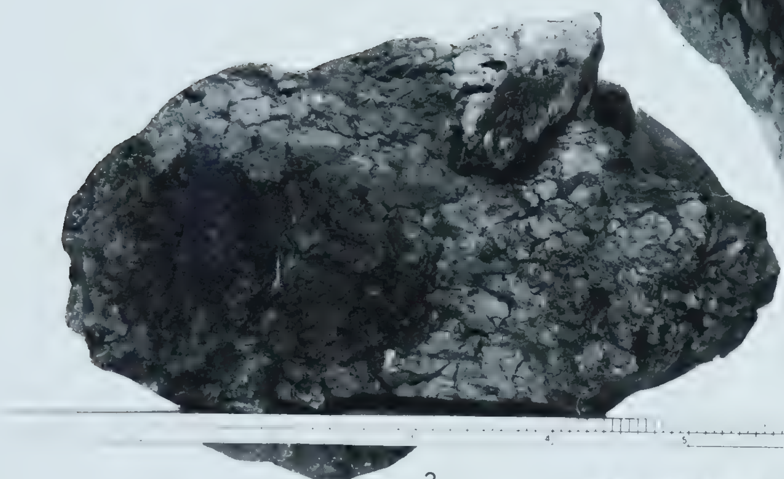
Gypsum crystals from the Regina Basin

Figure	
1	Oblique view of five selenite crystals beneath an organic zone in the Rouleau Terrace.
2	Top view of organic zone above selenite crystals, crystals show etching.
3	Selenite crystal which has been leached and shows secondary overgrowths, magnification X 2.
4	Leached crystal shown in Figure 1 and 2, shows secondary overgrowths, magnification X 2.
5	Fern? sporangia, lateral view, fractured for the escape of spores, generally black (sprayed with ammonium chloride), magnification X 26.



1

3



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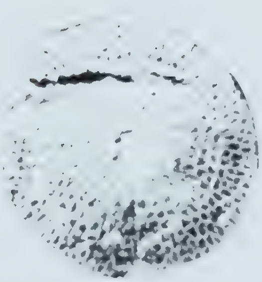

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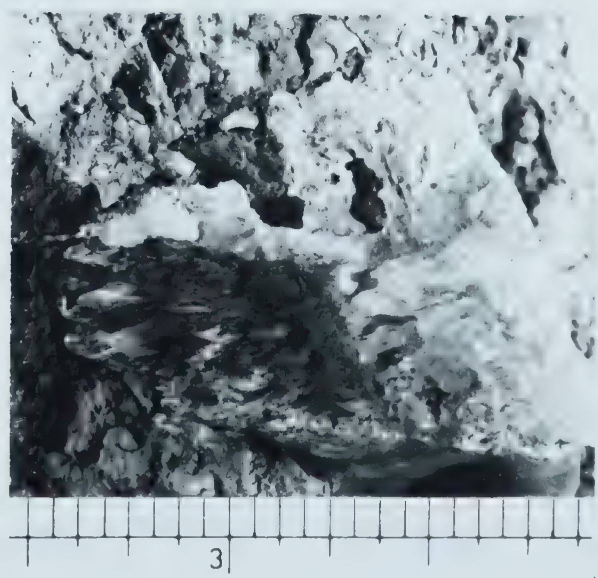
4 

PLATE 2

EXPLANATION OF PLATE 3

Vertebrates from the Rouleau Terrace

Figure

1-2 *Microtus pennsylvanicus* (Ord) skull;

1: dorsal view, magnification X 5.5.
2: ventral view, magnification X 5.5.

3-4 *Microtus pennsylvanicus* (Ord) right lower jaw;

3: occlusal view, magnification X 6
4: lingual view, magnification X 6, 2nd incisor extended.

5-6 *Microtus pennsylvanicus* (Ord) molar teeth;

5: lateral view of M_1, magnification X 12.5.
6: lateral view of M_2, magnification X 12.5.

PLATE 3

EXPLANATION OF PLATE 4

Fresh-water Ostracoda from the Regina area

Magnification X 40

Figure	
1	_Cyprinotus pellucidus_ Sharpe, Recent, Willowbunch Lake, Saskatchewan, right valve, oil immersed.
2-4	_Cypridopsis vidua_ (Muller), Pleistocene, Qu'Appelle Valley section, 2-right valve (oil immersed), 3-left valve (oil immersed), 4-carapace showing overlap of left valve (sprayed with ammonium chloride).
5-7	_Cyclocypris forbesi_ Sharpe, Pleistocene, Qu'Appelle Valley section, 5-right valve (oil immersed), 6-left valve (oil immersed), 7-carapace showing overlap of right valve (sprayed with ammonium chloride).
8-9	_Eucandona caudata_ (Kaufmann), Pleistocene, lower lacustrine unit Rocky Lake section, 8-right valve (oil immersed), note adductor muscle scar, 9-left valve (oil immersed), note adductor muscle scar.
10	_Eucandona fossulensis_ (Hoff), Pleistocene, Qu'Appelle Valley section, right valve (oil immersed), note adductor muscle scar.
11	_Eucandona ohioensis_ (Furtos), Pleistocene, Qu'Appelle Valley section, male left valve (oil immersed) note adductor, antennal, and mandibular scar positions.
12	_Eucandona poseyensis_ (Staplin), Pleistocene, Qu'Appelle Valley section, right valve, oil immersed, note adductor, antennal, and mandibular scar positions.
13-17	_Eucandona swaini_ Staplin, n. sp., Pleistocene, lower lacustrine unit Rocky Lake section, 13-female right valve (oil immersed), 14-female left valve (oil immersed), 15-male right valve (oil immersed), 16-male left valve (oil immersed), 17-female carapace (sprayed with ammonium chloride) showing overlap of left valve; note position of muscle scars and genital organs in oil immersed specimens.
18	_Eucandona_ sp. A, Pleistocene, Qu'Appelle Valley section female right valve, oil immersed.

PLATE 4

EXPLANATION OF PLATE 5

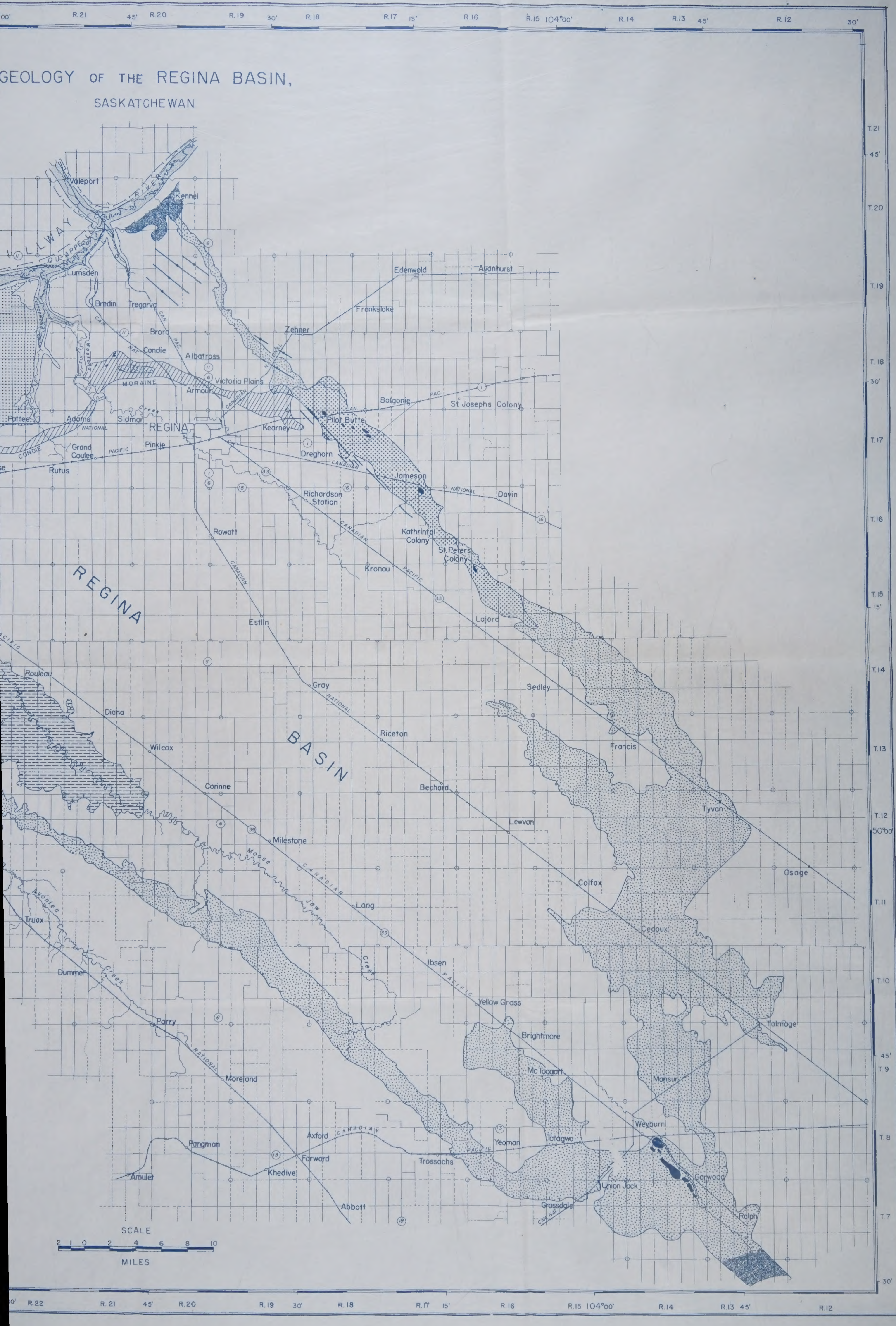
Fresh-water Ostracoda from the Regina area

All specimens sprayed with ammonium chloride, magnification X 40.

Figure	
1-2	*Ilyocypris bradyi* Sars, Pleistocene, Qu'Appelle Valley section, 1-right valve, 2-left valve.
3-4	*Ilyocypris gibba* (Ramdohr) Pleistocene, Rouleau Basin section, 3-right valve, 4-left valve.
5-6	*Cytherissa lacustris* Sars, Pleistocene, lower lacustrine unit Rocky Lake section, 5-right valve, 6-left valve.
7-10	*Limnocythere* sp. A Delorme, n. sp., Recent, Sturgeon marl, 7-female right valve, 8-female left valve, 9-male right valve, 10-male left valve.
11-14	*Limnocythere* sp. B Delorme, n. sp., Pleistocene-Recent Qu'Appelle Valley section, 11-female right valve, 12-female left valve, 13-male right valve, 14-male left valve.
15-18	*Limnocythere* sp. C Delorme, n. sp., Pleistocene, lower lacustrine unit Rocky Lake section, 15-female right valve, 16-female left valve, 17-male right valve, 18-male left valve.
19-22	*Limnocythere* sp. D Delorme, n. sp., Pleistocene, basal upper lacustrine unit Rocky Lake section, 19-female right valve, 20-female left valve, 21-male right valve, 22-male left valve.
23	*Limnocythere* sp. E Delorme, n. sp., Pleistocene, lower unit Rocky Lake section, left valve.
24-25	*Limnocythere* sp. F Delorme, n. sp., Pleistocene, lower lacustrine unit Rocky Lake section, 24-female right valve, 25-female left valve.
26-29	*Limnocythere* sp. G Delorme, n. sp., Pleistocene, lower lacustrine unit Rocky Lake section, 26-female right valve, 27-female left valve, 28-male right valve, 29-male left valve.

PLATE 5

GEOLOGY OF THE REGINA BASIN,
SASKATCHEWAN
EXPLANATION
GLACIAL LAND FORMS
End moraine
broad, gently sloping ridges, 15-100 feet high, 1/5-2 miles wide; till and ice-contact sand and gravel.
Washboard moraine
sub-parallel, discontinuous, generally arcuate ridges 5-30 feet high; till and minor amounts of sand and gravel; trend indicated by pattern.
Flutings
Straight, parallel ridges and grooves in till, blanketed by clay in the Regina Basin; relief 3-8 feet.
Kames, kame moraine, and kame-eskerine complexes. Concial and elongate hills of sand and gravel up to 40 feet high.
PROGLACIAL LAND FORMS
Regina Basin, Condie Plain.
Flat to rolling; clay and silt up to 70 feet thick.
SILT
SAND & GRAVEL
Fluvio-lacustrine plains.
Flat to undulating; sand and gravel 5-20 feet thick; fluvial and lacustrine, undifferentiated.
Eroded till plains.
Flat to undulating; sand, gravel boulder pavement 5 feet thick, and eroded till.
Washed till plains.
Flat to undulating, gently sloping, sand, gravel, boulder lag and eroded till.
Meltwater channels
Trend of small meltwater channels now occupied by permanent and intermittent streams, 1000 feet wide, 10 feet deep; till, sand, and gravel.
Valleys up to 150 feet deep and 1 mile wide, till, sand, gravel, alluvium, colluvium, and bedrock sand and clay.
Spillways.
Valleys up to 300 feet deep and 2 miles wide; till; sand, gravel, alluvium, colluvium, and bedrock sand and clay.
Glacial lake strandlines.
Marked by sand beaches less than 5 feet high and wave-cut cliffs up to 20 feet high.
POST GLACIAL LAND FORMS
Lake Rouleau Basin.
Flat; clay up to 16 feet thick.
Alluvial flood plain.
Flat to undulating, up to 11/2 miles wide; clay and silt, and sand up to 50 feet thick.
Postglacial strandlines.
Marked by eroded fault scarp in clay and till up to 25 feet high.
GEOLOGY BY D. L. DELORME
1960-1962
Approximate magnetic declination, 17°E.
Base map issued by Surveys and Mapping Branch, Department of Mines and Technical Surveys.
Cartography by F. Dimitrov, Department of Geology, University of Alberta, Edmonton, Alberta.
SCALE
MILES
QU'APPELLE SPILLWAY
REGINA
MOOSE JAW
LAKE ROULEAU BASIN
ROCKY LAKE MORAINE
MOOSE JAW MORAINE
Chamberlain
Valeport
Kennel
Lumsden
Disley
Bredin
Tregarva
Brora
Condie
Albatross
Victoria Plains
Armour
Kearney
Keeler
Marquis
Rowletta
Tuxford
Grayburn
Archydal
Belbeck
Caron
Caronport
Burt
Boharm
Curlew
Stony Beach
Keystown
Pattee
Adams
Sidmar
Grand Coulee
Pinkie
Eastview
Burdick
Madrid
Pasqua
Belle Plaine
Pense
Rutus
Rowatt
Stelcam
Drinkwater
Abound
Archive
Baildon
Tilney
Pitman
Estlin
Buttress
Levuka
Briercrest
Rouleau
Diana
Leakville
Hearne
Wilcox
Corinne
Claybank
Bayard Station
Gravelbourg Jct.
Avonlea
Truax
Dummer
Parry
Moreland
Pangman
Amulet



GEOLOGY OF THE REGINA BASIN,
SASKATCHEWAN
REGINA
BASIN
SCALE
2 1 0 2 4 6 8 10
MILES
R.21
R.20
R.19
R.18
R.17
R.16
R.15
104°00'
R.14
R.13
R.12
R.22
45'
30'
15'
T.21
T.20
T.19
T.18
T.17
T.16
T.15
T.14
T.13
T.12
50°00'
T.11
T.10
T.9
T.8
T.7
Valeport
Kennel
Lumsden
Bredin
Tregarva
Brora
Condie
Albatross
Victoria Plains
Armour
MORAINE
Pattee
Adams
Sidmar
REGINA
Kearney
Pilot Butte
Balgonie
St. Josephs Colony
Edenwold
Avonhurst
Frankslake
Zehner
Grand Coulee
Pinkie
Rutus
Dreghorn
Jameson
Davin
Richardson Station
Rowatt
Kathrintal Colony
St. Peters Colony
Kronau
Lajord
Estlin
Rouleau
Diana
Wilcox
Gray
Sedley
Riceton
Francis
Corinne
Bechard
Tyvan
Lewvan
Milestone
Osage
Colfax
Lang
Truax
Cedoux
Ibsen
Dummer
Yellow Grass
Parry
Talmage
Brightmore
McTaggart
Moreland
Mansur
Weyburn
Axford
Yeoman
Tatagwa
Pangman
Farward
Trossachs
Khedive
Amulet
Union Jack
Gorwood
Abbott
Grassdale
Ralph
CANADIAN
PACIFIC
NATIONAL
CAN. NAT.
Moose Jaw Creek
Wascana
Avonlea Creek
QU'APPELLE
RIVER
CONDIE